Informational Leaflet 87

PROCEEDINGS OF THE 1966 NORTHEAST PACIFIC PINK SALMON WORKSHOP

Edited by:

William L. Sheridan
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Juneau, Alaska

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STATE OF ALASKA
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DEPARTMENT OF
FISH AND GAME
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SUBPORT BUILDING, JUNEAU

E-R-R-A-T-A S-H-E-E-T

CORRECTIONS FOR INFORMATIONAL LEAFLET NO. 87

Page 16, paragraph 3; marine survival is 2.8 rather than 12.8 percent.

Page 97, Authors of article, "Western Juan de Fuca Strait Angling Data as an Indicator of Local Pink Salmon Stock Size," are Frank Haw and Ray Buckley, Washington State Department of Fisheries.

Page 104, paragraph 2; starting with line 9, text should read: "The extreme annual July length variation, from 1959 through 1965, occurred in 1961 and 1963 (Figure 2). The 1963 July length sample (Figure 2) is 7.5 times larger than the 1961 sample, yet there is a 5 cm. interval at the upper end of the 1961 curve which was unoccupied in 1963. Figure 3 shows the 1957 through 1965 relationship...."

Insert g. after 3,194 in last line of paragraph 3.

Insert "growth between salmon" and "depends", line one of paragraph 4.

[redacted]

FOREWORD

In January 1962 a group of fishery scientists met informally in Juneau, Alaska to discuss pink salmon. So many ideas and worthwhile information evolved from their discussions that the need for a more formal Pacific coastwise workshop became apparent. Dr. W. J. McNeil of the United States Bureau of Commercial Fisheries reported in Manuscript Report 64-5 on the first formal meeting, which took place in January 1964.

By February 1966 when the third meeting took place, pink salmon scientists were looking forward to exchanging the latest developments at these biennial meetings and to the stimulation provided by them. The meetings are now referred to as the Northeast Pacific Pink Salmon Workshop. Fishery scientists from Oregon, Washington, British Columbia, and Alaska, an area which encompasses the entire range of North American pink salmon, now normally attend the pink salmon workshop.

Workshop topics for the 1966 meeting were selected from a list of management needs made apparent at the 1964 meeting. In order of importance, these were:

(1) The development of methods for forecasting runs.
(2) The determination of threshold, or optimum levels of escapement.
(3) The economic evaluation of resource and cost-benefit relation.

It is apparent from these subject headings that pink salmon research today is aimed at solving the management problems currently facing us. There are still gaps in our knowledge of pink salmon; nevertheless an air of optimism prevailed at the 1966 workshop. Significant breakthroughs were reported, and near breakthroughs in other phases appeared to be close-at-hand.

Central Alaskan forecasts from pre-emergent fry indices have continued to prove accurate; these mark the first consistent pink salmon forecasts. Extreme variability in early marine survival has been detected in central British Columbia, signaling the need for a different approach to forecasting than required in Central Alaska. The best forecast approach in the heart of the pink salmon range, Southeastern Alaska, remains undecided.

Basic understanding of factors controlling success of spawning is gradually emerging, but much is still unknown. Definition of optimum escapement is now possible in a few areas of the Northeast Pacific. Rehabilitation and some stabilization of the pink salmon population will be the benefits derived from this line of research.

Sales records indicate an increased demand for pink salmon, making it incumbent upon fishery scientists to continue to work towards a knowledge of how to increase production through management techniques. We can then more intelligently utilize this renewable resource.

Charles H. Meacham
Division of Commercial Fisheries
Alaska Department of Fish and Game

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PROCEEDINGS OF THE 1966 NORTHEAST PACIFIC PINK SALMON WORKSHOP

Edited by

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U. S. Forest Service
Juneau, Alaska

INTRODUCTION

The 1966 Northeast Pacific Pink Salmon Workshop met in the Bureau of Commercial Fisheries Technological Laboratory in Ketchikan, February 8-10. About fifty people attended the Conference. A list of those attending and their agencies is given in Appendix 2.

Steering Committee members were: Charles H. Meacham (Chairman), Donald E. Bevan, Earle Jewell, W. H. Noerenberg, W. L. Sheridan (Rapporteur), F. V. Thorsteinson, Charles E. Walker, and Carl Wilson.

Included in these proceedings are papers and abstracts of papers that were presented under the major topics of "Optimum Escapement," "Forecasting Pink Salmon Runs," and "The Future of Pink Salmon." The results of the questionnaire (similar to the one issued in 1964) are given in Appendix 1.

In 1964 the three top research needs designated by attending scientists were, in order of priority: (1) development of methods for forecast, (2) determination of threshold, or optimal levels of escapement and (3) economic evaluation of resource and cost benefit relation. Methods for forecast and determination of optimum escapement levels were also listed as Number 1 and Number 2 priorities in 1966. Economic evaluation was, however, replaced by Freshwater Ecology.

The panel on optimum escapement stressed two general needs. First, there is a need for more research to define the number of salmon that are needed for spawning and the number that should be taken from each stock by the commercial fishery. These facts are essential for proper harvest of the fishery under the maximum yield concept and for protection against the encroachment of foreign competition.

Second, there is also a need for further definition of factors which cause variations in the escapement return relationship. In spite of gaps in present day knowledge, the prediction that in Prince William Sound definition of optimum escapement will become a reality in 3-4 years and that in a large river system in British Columbia optimum escapement has already been defined, were heartening.

The conclusion of the optimum escapement panel was that evidence that freshwater abundance places a maximum upper limit on overall abundance is increasing. This means that the pink salmon fisheries should be managed to produce the highest possible yield of fry.

The panel on "forecast" included discussions of attempts to forecast abundance of return runs of pink salmon by several methods. Predictions meeting with more or less success have been based on: (1) abundance of spawners during the previous cycle, (2) abundance of fry the previous year, (3) abundance of juveniles in estuarine and inshore waters, (4) abundance of immature and mature salmon in coastal waters and on the high seas and (5) relating abundance of returning pinks to abundance of chum salmon of the same brood year two years later.

One of the most promising methods discussed was prediction based on abundance of immature pinks in outside coastal waters. In the summer of 1964 millions of immature pinks were found migrating northward along the coasts of British Columbia and Alaska in a belt about 15 miles wide. In 1965 the pattern was the same, indicating that juvenile pink salmon, upon entering the coastal waters, proceed northward in a concentrated belt, close to shore.

The panel on the "Future of Pink Salmon" expressed their views on a note of guarded optimism. From the processing standpoint it was concluded that, although current packs are of good quality, refinements are forthcoming in the way of better harvesting, processing and marketing. It was pointed out that for most efficient management of the stocks the manager must work close to the spawning grounds, but as the fish approach the spawning grounds there is a gradual decline in quality.

Economically, the long range demand for pink salmon appears favorable. On the other hand, too much gear might damage the resource. One of the biggest problems in marketing canned salmon appears to be the highly fluctuating nature of the supply. In a year of large supply a large market must be developed. When a year of large supply is followed by one or more years of low supply, the market dwindles and must be re-developed when the supply increases.

Each pink salmon workshop has been interesting in itself and for the progress that it portrays. Those biologists (and others) who have been associated with pink salmon research and management for some years cannot help but see and be impressed by the progress that has been made during the last fifteen years.

OPENING ADDRESS ON OPTIMUM ESCAPEMENT

Wallace H. Noerenberg, Alaska Department of Fish and Game

I think we will all agree that optimum escapement is the principal ingredient of our definition of maximum sustained yield in the salmon fisheries. It is basic to the success of our management and thus directed to the well being of all elements of the fishing industry. It is also basic to our respective national rights to maintain, within practical limits, exclusive use of our various fisheries.

Progress in achieving refined optimum escapement in management of the salmon fisheries has been quite poor and I say this in an international sense. I believe most of us in the management field cannot honestly say we are as yet on firm ground, either regarding definition of optimum escapement in the streams in question, or our ability to manipulate to achieve desired levels of escapement. In Alaska, the trend whereby pink salmon fishery catches are being made farther and farther from the spawning streams is increasing the problem of achieving optimum escapement. Granted, the objective of better quality of product is fine; but we have often eliminated the possibility of managing the races of salmon separately and thus reduced our chances of achieving desired escapement on a stream by stream basis.

Today, this panel will review some general as well as specific research on pink salmon optimum escapement. George Hirschhorn, Bill McNeil and Bob Roys, will deal with some fairly broad concepts; i.e. evidence of identifiable optimums at the district or subdistrict level. Howard Smith, Jack Bailey and Jack Helle will deal with evidence from specific streams. I believe the evidence presented today will indicate we are in fact making progress in understanding the factors contributing to success and failure of spawning escapements. In certain districts, such as Prince William Sound, we appear to be reasonably close to defining optimum escapement levels in terms which can be of practical use to the management biologist.

SPAWNER-RECRUIT RELATIONSHIPS IN SOME STOCKS OF ALASKAN PINK SALMON

George Hirschhorn, Bureau of Commercial Fisheries, Seattle

Spawner-recruit relationships for salmon have been studied for some time, but the original U.S. case for abstention before the International North Pacific Fisheries Commission in 1956 did not include functions as such. The U.S. position was that available data indicated that an increase in the exploitation or fishing rate failed to sustain an increased catch of the stocks involved. For U.S. pink salmon these data consisted mainly of historical catch-effort statistics.

Japan later insisted on mathematical demonstrations; spawner-recruit curves accordingly appeared in INPFC documents (224) in 1958. These were essentially freehand curves supporting the original U.S. position against additional fishing pressure. For Alaskan stocks of pink salmon, the only available long-term series of data were annual records of catch and effort going back to 1934 for Kodiak and Alaskan Peninsula runs, and to 1927 for S.E. Alaska runs.

Runs or escapements can be estimated if exploitation rate is known, using the relationship:

Run = Catch/μ where $\mu = 1-e^{-qf}$ is the exploitation rate of the catchability coefficient and f the amount of effort. Since q is unknown, the actual exploitation rate is unknown. However, the true exploitation rate is likely to be included in a range of 30-70% and the corresponding estimates of run size are likely to include the true run size. Such estimated run sizes can then be fitted with different S-R curves.

Three well-known functions--those of Ricker, Beverton and Holt, and Schaefer--were fitted to values of escapements and subsequent returns computed in this manner. Source data are catch and effort figures for the Alaska Peninsula, Kodiak and Southeastern Alaska stock units of pink salmon. Escapement and return estimates were based on assumed average exploitation rates ranging from 30 to 70 percent for a total of 75 fittings.

The parameters of each fitted curve are weighted, least-square estimates of constants of regression. These were obtained by regressing linear transforms of the functions of Ricker, Beverton and Holt, and Schaefer. The data were weighted before regression because the expected error curve of returns for fixed levels of escapement was taken to be log-normal rather than normal. The weights are the square deviations of the derivatives of ln R/S with respect to the particular return function. For that or Ricker, weighting is unnecessary since the derivative is one. For the Beverton-Holt function $(D_{S/R} \ln R/S)^2 = [D_{S/R} (\ln (S/R)^{-1})]^2 = (R/S)^2$, and for the Schaefer function $[D_{R/S} (\ln R/S)]^2 = (R/S)^{-2}$. Sums of the squared differences between estimated yearly returns and expected yearly return under the different functional relationships between escapement and return are shown in Table 1. Symbols H1, --, H5 imply that the following Y-variables of regression were used in finding the parameters for the curves:

H 1	$Y = \ln R/S$	(Ricker)
H 2	$Y = S/R$	(Beverton-Holt)
H 3	$Y = S/R,\ w = (R/S)^2$	(Beverton-Holt)
H 4	$Y = R/S$	(Schaefer)
H 5	$Y = R/S,\ w = (R/S)^{-2}$	(Schaefer)

If the standard of comparison is the mean squared deviation of the returns from their mean (Ho), mean squares from fitted curves may give higher or lower values. Table 1 shows that only Ricker curves gave lower values of mean square in all 15 comparisons. The maximum amount of reduction was associated with Ricker curves (H1) in 10 of these, with Schaefer curves (H4) in 4; in one comparison these two functions gave the same mean square.

In another kind of comparison, the range of the different function estimates of harvestable excess may or may not include the observed mean yearly catch for each area. If the mean annual catch is closer to the excess predicted from a particular function than from others, that function may be considered more plausible than the others. Table 2 gives the data for this comparison. The Ricker function seems preferable from this standpoint as well, since the average commercial catch is either contained in the range of harvestable excess (in case of Alaska Peninsula pinks), or lies close to one of the extremes. Ranges from other functions were either considerably higher, or lower values than the value of mean annual catch.

Instead of comparing ranges, one may compare only the estimated excess values that correspond to 50% exploitation rates (table 2, col. 3). Again, the agreement of mean catch with predicted excess is best for the Ricker values.

Inasmuch as actual escapement levels are unknown, the effect of potentially higher, or lower, escapements on subsequent production cannot be dealt with directly. However, the agreements of mean catch with Ricker estimates were best when the assumed level of exploitation was high (60-70%) and worst for levels at the low extreme of the range. At low levels of exploitation rates the estimated return values are larger, and so are values of harvestable excess (table 2). From this standpoint, it seems unlikely that future increases in exploitation rate can cause a sustainable increase in production.

Table 1. Mean square differences between estimated returns and expected values.

	Assumed mean exploitation rate (percent) 30	40	50	60	70
1. Alaskan Peninsula					
H 0	93.1	51.3	32.2	21.8	15.7
H 1	66.5	37.9	24.8	17.7	13.6
H 2	80.7	45.8	29.7	21.0	15.8
H 3	91.6	54.4	37.5	28.7	23.3
H 4	63.6	39.8	30.7	30.9	44.3
H 5	104.3	58.1	36.9	25.5	18.8
2. Kodiak					
H 0	141.3	77.6	48.5	33.0	23.9
H 1	128.1	69.6	43.2	29.2	21.2
H 2	152.9	83.7	52.3	35.7	26.1
H 3	157.2	85.8	53.5	36.3	26.3
H 4	125.4	68.2	42.5	29.2	22.0
H 5	187.5	100.5	61.4	40.9	29.3
3. S.E. Alaska					
H 0	2075.4	1167.9	748.9	522.2	386.4
H 1	1829.9	1040.0	677.4	484.1	372.4
H 2	2200.1	1245.2	806.4	571.3	433.9
H 3	2244.9	1273.4	826.6	586.8	445.6
H 4	2333.7	1397.2	982.8	790.4	737.3
H 5	3384.1	1904.4	1225.8	863.2	651.7

Table 2. Estimates of harvestable excess, and mean observed catch.

	Harvestable excess with Assumed mean exploitation rate (percent)				
	30	40	50	60	70
1. Alaskan Peninsula Mean Annual Catch	3.80	3.80	3.80	3.80	3.80
H 1	3.61	3.57	3.67	3.79	3.93
H 2	1.66	1.84	2.03	2.18	2.37
H 3	10.85	9.23	8.29	7.55	7.09
H 4	7.13	6.65	6.52	6.73	7.27
H 5	0.00	0.11	0.47	0.96	1.46
2. Kodiak Mean Annual Catch	7.34	7.34	7.34	7.34	7.34
H 1	9.87	8.67	8.09	7.82	7.80
H 2	11.19	9.31	8.32	7.70	7.63
H 3	15.37	12.72	11.29	10.42	9.92
H 4	12.37	10.93	10.22	9.95	10.02
H 5	4.16	4.53	4.96	5.48	5.99
3. S.E. Alaska Mean Annual Catch	23.7	23.7	23.7	23.7	23.7
H 1	28.54	25.90	24.75	24.35	24.38
H 2	14.38	13.98	14.25	14.95	16.01
H 3	59.44	48.59	42.44	38.66	36.19
H 4	48.08	41.98	38.87	37.36	37.13
H 5	0.00	0.01	1.43	4.37	8.25

MORTALITY FACTORS DURING THE SPAWNING SEASON

John H. Helle, Bureau of Commercial Fisheries, Auke Bay

Summary

The difference between potential and actual egg deposition represents one of the most disastrous periods in terms of mortality during the pink salmon (Oncorhynchus gorbuscha) reproductive cycle. Factors contributing to mortalities in this period are related to interactions between timing, distribution, density, and behavior of spawners.

At Olsen Creek in Prince William Sound, Alaska, the duration of pink and chum salmon (O. keta) spawning runs is nearly three months. Chums first enter the stream in mid-June and reach peak numbers in July. The run continues into early September. Pink runs begin in early July and finish about mid-September. The pink runs tend to be bimodal on both the even and odd year cycles. On the even year the early run utilizes the whole stream and the late run is strictly intertidal; on the odd year all of the runs distribute themselves throughout the stream. Redd superimposition, between spawning groups due to timing and distribution of spawners and also within groups due to density and behavior, has been demonstrated at Olsen Creek.

Several other density associated mortality factors have been observed. For example when the main spawning areas are crowded, fish are forced to spawn in unproductive areas; e.g. lower intertidal areas and intermittent channels. We have not found over winter survival below the six foot tide level at Olsen Creek although considerable spawning does take place in this area under high density situations. We have found high egg retention associated with high spawner density.

Intraspecific and interspecific behavior on the spawning grounds can also result in mortalities. Areas that come under continuous spawning pressure during the long spawning season have been studied to determine efficiency of utilization. From comparisons with known egg samples we have found that frequently 2 to 4 and as many as 7 females have spawned in the same site.

We have had some success in attracting females to artificial redds (depressions in the stream bottom dug with a shovel) and to areas cleaned of silt and fine particles with a hydraulic pump. This tendency of females to favor the same sites for spawning needs further research.

Egg deposition is limited to the egg-carrying capacity of the spawning bed. In the upper intertidal area at Olsen Creek the capacity was measured for three years and was about 5,000 eggs per square meter. Spawning continued after this figure was reached, resulting in a final egg deposition somewhat lower than the carrying capacity. In other words, females dug up more eggs than they deposited. The extent to which this situation occurs in other portions of the stream is not known.

Mortalities resulting from climatic conditions are largely unpredictable; e.g. egg dislodgment by stream degradation during floods (or through a combination of spawning activity and flooding), egg suffocation caused by stream aggradation during floods, spawning in intermittent channels as on bars during floods, reduction in available DO during low water periods, and freezing (order of occurrence of freezing temperatures and snowfall). Mortalities during the spawning season attributed to interactions between timing, distribution, density, and behavior could, however, be predicted. Evaluation of these mortality factors will lead to a better understanding of what constitutes the most efficient escapement to any given spawning stream.

EFFECTS OF SALINITY ON INTERTIDAL PINK SALMON SURVIVAL

Jack E. Bailey, Bureau of Commercial Fisheries, Auke Bay

Field ecology studies of intertidal spawning pink salmon at Olsen Creek in Prince William Sound, Alaska, have revealed where fry production occurred with respect to tidal inundation. The lowest elevation at which pre-emergent fry production occurred was at the 6-foot tide level of Olsen Creek. For management purposes, fry production in Prince William Sound streams is generally conceded to be limited to areas above the 8-foot tide level. The 6-foot level of Olsen Creek was inundated by sea water approximately 50 percent of the time and the 8-foot level approximately 33 percent of the time (Helle et al., 1964).

Sea water per se was not the only potentially limiting factor encountered in intertidal Olsen Creek. Tides induced significant fluctuations in salinity, temperature, and interchange of gravel water with surface water. Each factor was associated with tides or proximity to sea level in such a way that the closer a salmon redd was located to sea level, the more adverse was the environment for eggs and larvae. Because of the complexity of relationships between these factors and fry production in the natural environment, it was impossible to determine how far seaward fry production might extend if, for example, interchange potential of the egg environment were improved.

Laboratory studies with a simulated intertidal environment were initiated in 1964 at the Auke Bay Biological Laboratory to study the effects of sea water on incubating salmon eggs. Fresh water from Auke Lake and sea water from Auke Bay were supplied unfiltered to egg containers through a system of mixing tanks, siphons, and electro-hosecocks which were controlled by electric timers.

Pink salmon eggs were subjected twice daily to simulated tidal exposures for periods ranging from 1.5 to 12 hours at concentrations of sea water ranging from 12 to 30 $^{o}/oo$. The 1.5 hour-tidal exposure was comparable to the 10-foot tide level, or the upper intertidal zone of Olsen Creek in percent of time exposed to sea water. The 4-, 6.67-, and 9.33-hour exposures were comparable respectively to the 8-, 6-, and 4-foot tide levels of Olsen Creek. The 12-hour tidal exposure was actually continuous exposure to sea water.

Eggs for the various experiments were artificially stripped and fertilized from adult pink salmon at the following streams: intertidal Fish Creek on Douglas Island, intertidal Lovers Cove Creek on Baranof Island, Auke Creek near the laboratory, and Hood Bay Creek on Admiralty Island. The eggs were transported to the laboratory in styrofoam insulated plastic containers. Mortality due to unfertilized eggs and mechanical injuries during transportation amounted to less than 6 percent.

The effects of sea water on incubating eggs were evaluated on the basis of head widths of 2-week- or 3-week-old embryos, total lengths of larvae and fry, mortalities, and occurrence of deformed embryos.

Results

There was a 100-percent mortality of eggs during the first 12 days at 28 $^{o}/oo$ for 9.33 hours twice daily and a 50-percent mortality at 28 $^{o}/oo$ for 6.67 hours twice daily. At 28 $^{o}/oo$ for 4 hours twice daily, there were no adverse effects attributable to sea water. Buttoned-up fry reared at this dosage level were not significantly different in size or general appearance from fry reared in fresh water. Milder concentrations of sea water, 10 to 15 $^{o}/oo$, in tidal exposures of 4 hours or less had no adverse effects on embryos and even appeared to enhance growth of some lots. It was not possible to determine whether the accelerated growth resulted from the mineral content of the water (as suggested by Rockwell, 1956) or from the slight warming action of the simulated tides.

Eleven-week-old fry completed development to the buttoned-up fry stage at age 14 weeks in 30 $^{o}/oo$ sea water with no fresh water respite. The fry held in sea water were not significantly different in size at age 14 weeks from fry held in freshwater or fry held in an intertidal environment. Pink salmon reared in these experiments developed the ability to withstand the transition from freshwater to full strength sea water before they reached the emergent fry stage. This was true of fry that were reared in fresh water as well as fry reared in a simulated intertidal environment.

Eggs that were fertilized and water hardened for 10.5 hours in 3.74 ‰ sea water yielded a high incidence of deformed embryos when incubated in a simulated intertidal environment. The deformed larvae had truncated tails, lordosis, and a high degree of variance about the mean lengths at age 3 weeks. The same eggs when transferred from the 3.74 ‰ fertilization and water-hardening medium to a fresh-water environment for incubation, yielded larvae that were normal in general appearance and size at age 3 weeks.

Conclusions

Pink salmon eggs fertilized in fresh water can withstand exposure to sea water at a tidal dosage level that approximates the maximum salinity experience of eggs and larvae at the 8-foot tide level of Olsen Creek. Higher dosage levels in the simulated intertidal environment caused mortalities, and it was concluded that sea water has a limiting effect on fry production below the 8-foot-tide level of Olsen Creek. Little if any production can occur below the 6-foot level, owing to the direct effects of saline water. These relationships may have a significant bearing on management decisions concerning the location and construction of pink salmon spawning ground improvement projects,

Literature Cited

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Rockwell, Julius, Jr.
1956. Some effects of sea water and temperature on the embryos of Pacific salmon, Oncorhynchus gorbuscha (Walbaum) and Oncorhynchus keta (Walbaum). Ph.D. Thesis, Univ. Wash., Seattle, 416 p.

DISCUSSION

Mr. Koski: Were any measurements made of robustness of fry from the different experiments?

Mr. Bailey: No measurements were made, but we intend to do this in the future.

Mr. Noerenberg: In years of low runs management has bred for the pink salmon that spawns in the 4-8 foot intertidal zone. This is the last 20 percent of the run that enters Prince William Sound. Regulations, especially in the fifties, favored intertidal spawners.

Mr. Simon: Was the salinity of water in the gravel measured?

Mr. Bailey: Yes, maximum salinity in the gravel could be attained in any part of the intertidal zone, depending on salinities in the bay. These salinities were 10-15 $^{o}/oo$ in July and by late September had risen to 27-28 $^{o}/oo$. Water in the gravel was usually within 1 $^{o}/oo$ of water above the gravel.

Mr. Helle: The most saline water was at redd depth.

Anon: What was the flushing rate?

Mr. Bailey: It varied from point to point. Up to 1/2 hour in clean spots (with very fine material mixed with gravel) while in some places in the upper intertidal zone water remained at 2 $^{o}/oo$ until the next high tide.

LAKELSE RIVER PINK SALMON

Howard D. Smith, Fisheries Research Board of Canada, Nanaimo, B. C.

Summary

Skeena River pink salmon have been fished commercially since about 1904. Catch data show a general upward trend in annual landings until 1925. The odd-year run failed in 1927 and the even-year run failed in 1932. Throughout this 1904-1930 period there was a well-defined even-year dominance. Runs have been generally poor since 1930 and except for a period during the 1950's there has been no apparent dominance in this period in either odd- or even-year lines.

More than 90 percent of Skeena pinks spawn in 3 tributaries and the Skeena mainstem. In the last few years the principle tributary stock has failed badly and the immediate future of Skeena pink salmon production now appears vested in a single stock spawning in the Lakelse River.

Escapement and fry production have been measured on the Lakelse River in brood years 1959-1965. During this period escapements have ranged from 122 to 1,321 thousand--a ten-fold difference. Spawning densities associated with these escapements have ranged from 0.3 to 2.8 fish per square yard. Average freshwater survival has been 13.3 percent, average marine survival 12.8 percent, and the ratio of return from parent spawners has been about 3.9:1.0.

Curves have been fitted to points relating escapement size to fry produced, percent survival and total return. These suggest that efficiency of reproduction (ratio of adult spawners to numbers of viable fry at time of seaward migration) has been about proportional to numbers in escapements ranging from 122-635,000 fish.

Escapements of 1,321 and 835 thousand pink salmon spawned in the Lakelse River in 1964 and 1965 respectively. The returns from these brood years are incomplete at time of reporting, but indicate a substantial reduction in efficiency from brood year 1964 and possibly some reduction in brood

year 1965.

These and other data bearing upon Lakelse River pink salmon production suggest an optimum escapement of about 800,000.

DISCUSSION

Mr. Fredin: How closely can you estimate the catch of Lakelse fish?

Mr. Smith: In recent years quite well, because catches in other areas have been low. In the late fifties and early sixties, when the Kispiox was producing more salmon, the separation was more difficult. There have been too, a number of tagging experiments which have given estimates in the estuary and an idea of abundance by weekly fishing periods. We hope to continually improve the accuracy of our estimates.

Mr. Simon: You estimated abundance in freshwater by tagging?

Mr. Smith: Yes, except in 1960, 1961, and 1962 when a counting fence was operated.

Mr. Simon: You don't attempt to estimate by making observations from the air?

Mr. Smith: We have made estimates from the air throughout the Skeena for both pinks and sockeye and we attempt to relate these estimates with those in Lakelse.

Mr. Simon: It is our experience that when the estimates get around a half million the situation becomes confusing.

Mr. Rosier: Did you predict the large run in 1964?

Mr. Smith: No, we predict total run each year on the basis of ratio of return for the entire system.

Mr. Roys: It is interesting that different areas are exhibiting the same type of curve. In Prince William Sound, however, this curve will possibly be steeper on the descending limb because of our estimates.

Mr. Gilbert: You implied doubt as to whether or not fish returning to Lakelse were really Lakelse fish. Do you have information to indicate straying?

Mr. Smith: I didn't mean to make such a strong implication. I do think, however, that possible straying is something we should all keep in mind, because we must be certain we are dealing with discrete stocks.

Mr. Martin: I wonder if timing was involved in the decline of the Kispiox run? Is there evidence of unusual environmental conditions bearing on the decline?

Mr. Smith: The Kispiox run occurred in the odd years. There haven't been many fish in the even year run for a long time. In brood year 1961 there were heavy ice jams in the river and in the spring we had very high water and disproportionate numbers of yolk fry in the samples.

Mr. Martin: When do the Kispiox fry migrate?

Mr. Smith: Kispiox downstream migrants are a bit earlier than Lakelse migrants. The migration generally becomes earlier as you go up-country.

POTENTIAL EGG DEPOSITION BY PINK AND CHUM SALMON AND RESULTANT FRY PRODUCTION

William J. McNeil, Bureau of Commercial Fisheries, Auke Bay

Management of salmon stocks for maximum sustained yield requires knowledge about the capacity of the environment to support salmon. Theoretical reproduction curves relating the number of salmon constituting a stock at some late life-history stage to potential egg deposition have been formulated by Ricker (1954, 1958a, 1958b), Beverton and Holt (1957), and Larkin, Raleigh, and Wilimovsky (1964). The curves vary in shape according to their underlying assumptions; but all of them impose an upper limit to the size of the population.

Shape of a reproduction curve is fixed by mortality processes causing the mortality rate to change as density of the population changes. The proportion of the total population dying can increase (direct density-dependent mortality) or decrease (inverse density-dependent mortality) as density of the population increases. Direct density-dependent mortality limits the maximum number of survivors and inverse density-dependent mortality inhibits small populations from increasing. Figure 1 illustrates four hypothetical reproduction curves. The curves OCA and OCB exhibit effects of direct density-dependent mortality only; whereas, curves ODA and ODB exhibit effects of direct and inverse density-dependent mortality. The curves OCA and ODA approach an upper limit asymptotically (asymptotic curves); while OCB and ODB have a maximum (dome-shaped curve).

Evaluating the true shape of the reproduction curve for a salmon stock is made difficult by yearly variations in mortality rates. The variability is often caused by mortality processes which act independently of density of the population (density-independent mortality). Data on the number of pink and chum salmon fry migrating from Hooknose Creek, British Columbia, and potential egg deposition (Hunter, 1959; Parker, 1962) illustrate how density-independent mortality may obscure the shape of a reproduction curve. If there was no density-independent mortality, points relating the number of fry to potential egg deposition would describe the capacity of Hooknose Creek to produce pink and chum salmon fry over a range of potential egg deposition up to 34 million (fig. 2). But the points are widely scattered.

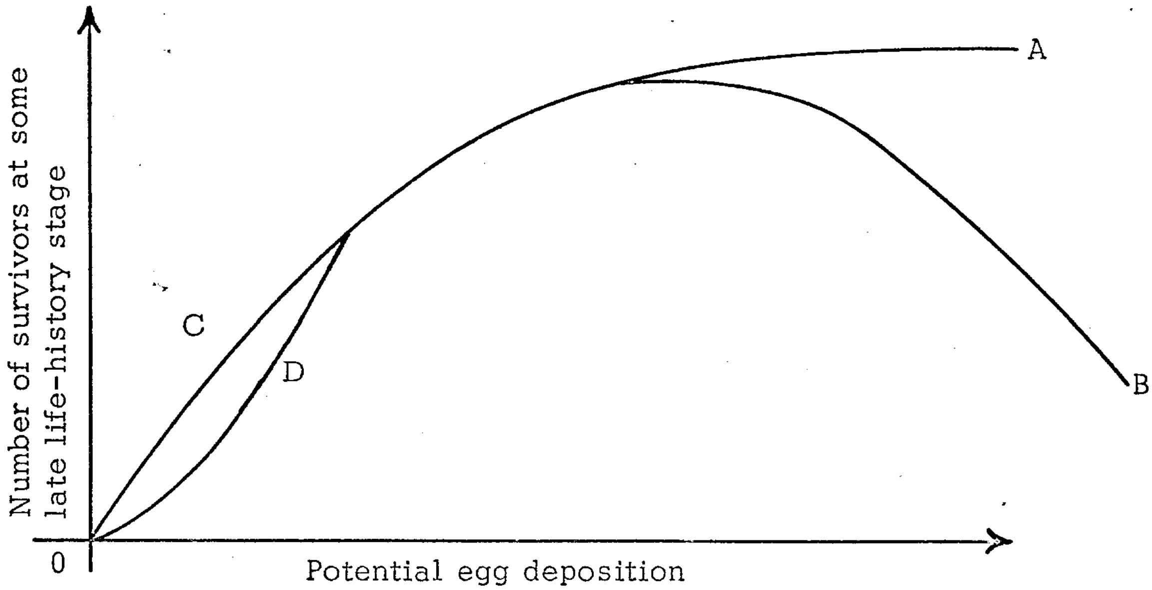

Figure 1. Hypothetical reproduction curves of a salmon stock.

Five million eggs, for example, produced 0.7 million fry in one year and 1.4 million in another; seven million eggs produced 0.2 million fry in one year and 1.2 million in another. Such variability, which I attribute to density-independent mortality, obscures the true relationship between potential egg deposition and fry production.

Sketched in figure 2 are three alternative curves describing reproduction of pink and chum salmon in Hooknose Creek which I believe can be hypothesized with existing data. Neave (1958) hypothesized that maximum production would be less than 2 million pink and chum salmon fry in Hooknose Creek and that production would decline from its maximum level where potential egg deposition exceeded 12 million.

Production of the maximum number of pink and chum salmon fry would be beneficial if density-dependent processes limiting population size operate solely in fresh water. This would mean that the number of adult salmon would increase with increased numbers of fry migrating to sea, (fig. 3), and that the freshwater rather than the saltwater environment would be limiting. Evidence supporting or contradicting the hypothesis that freshwater mortality places a maximum upper limit on abundance is meager; but if correct, the

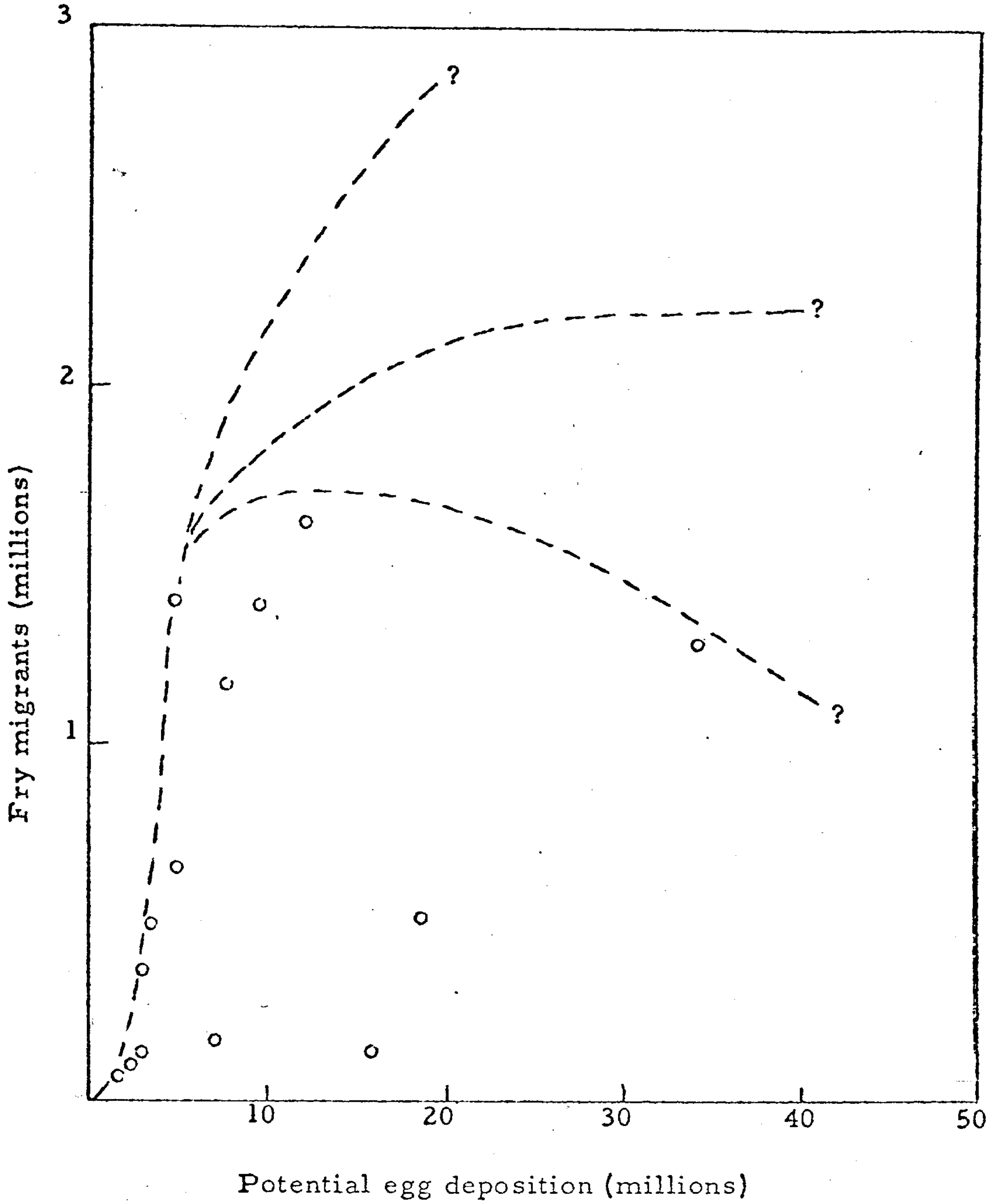

Figure 2. --Number of pink and chum salmon fry migrating from Hooknose Creek, British Columbia, in relation to potential egg deposition. Three hypothetical curves show alternative shapes of the freshwater reproduction curve.

fishery should be managed to maximize the number of fry produced.

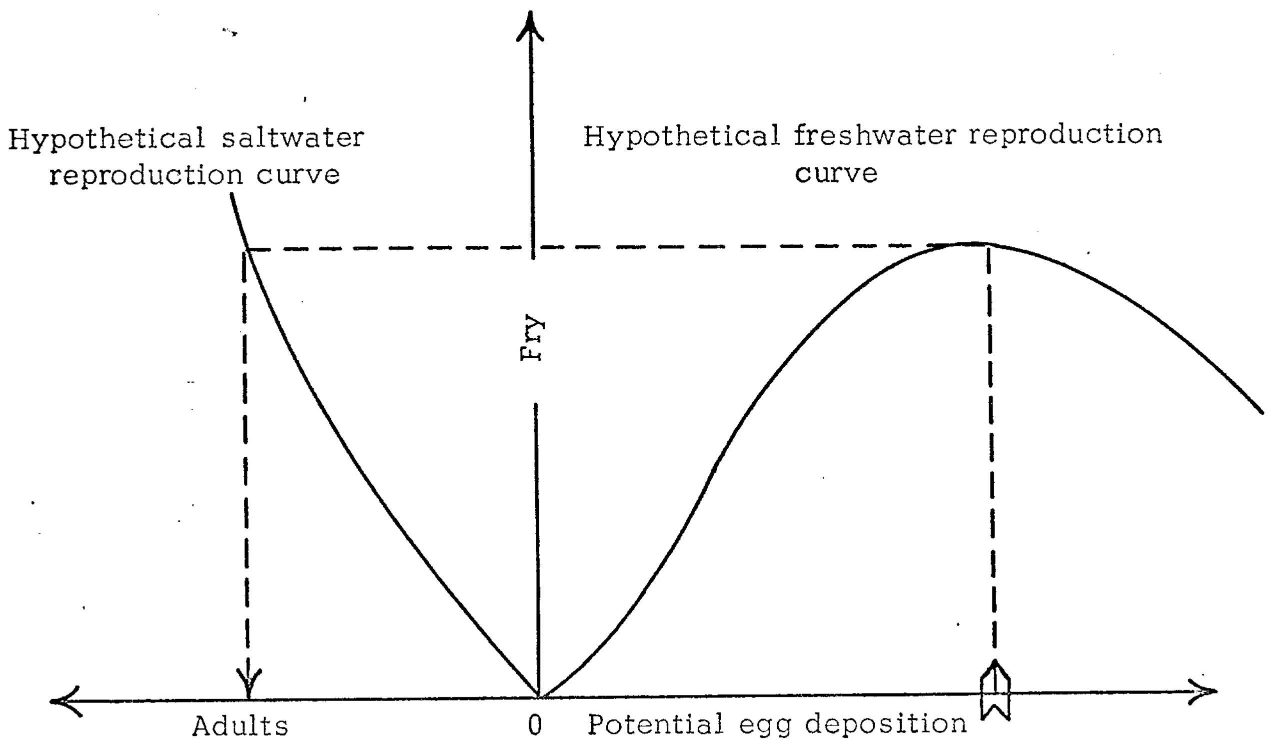

Figure 3. Hypothetical freshwater and saltwater reproduction curves illustrating case where production of fry limits production of adults.

Data on number of fry migrating to sea and potential egg deposition in seven pink and chum salmon spawning streams are summarized in table 1. Estimates of fry production are compared directly because the amount of spawning ground has been measured in each study stream. Estimates for Sashin, Whale Pass, Pleasant Bay, Disappearance, and Hooknose Creeks are for pink and chum salmon. Estimates for McClinton Creek are for pink salmon only since occurrence of chum salmon has not been reported. Sockeye and coho salmon spawners are abundant along with pink and chum salmon in Karymaisky Spring and utilize the same spawning ground. Most young of the four species migrate from the spring to a larger river as fry (Semko, 1954) and all are combined in estimates of potential egg deposition and fry production. In combining species, I assume that sockeye and coho salmon spawners can be substituted for pink and chum salmon spawners without affecting relationships between fry production and potential egg deposition.

Observed potential egg deposition in the seven streams has ranged between 3 and 6,507 per m^2. and fry production between 0 and 684 per m^2. Table 2 gives data from table 1 grouped according to the number of fry produced per m^2. Fry numbering 100 or less per m^2. are arbitrarily assigned to a "low range", and fry numbering more than 100 per m^2. to a "high range". The high range is further divided into three levels: (1) 101 to 200, (2) 201 to 300, and (3) more than 300 per m^2.

The data suggest that very high levels of fry production occur within a relatively narrow range of potential egg deposition. Although more than 100 fry per m^2. were produced where potential egg deposition ranged between 703 and 6,500 per m^2., production of over 300 fry per m^2. occurred only where potential egg deposition ranged between 2,300 and 4,400 per m^2. This would require 1.7 to 3.3 chum or 2.4 to 4.6 pink salmon spawners per m^2. of spawning ground, assuming an equal sex ratio.

Table 1. Area of spawning ground and estimated potential egg deposition and fry production in pink and chum salmon spawning streams.

Stream	Area of spawning ground	Brood	Potential egg deposition per m².	Fry production per m².
	M².	Year	Number	Number
[1] Sashin Creek Southeastern Alaska	13,629	1940	3,878	249
		1941	6,507	75
		1942	5,789	49
		1943	1,114	17
		1944	325	10
		1945	384	3
		1946	55	0.1
		1947	112	2
		1948	76	1
		1949	365	13
		1950	13	0.0
		1951	324	31
		1952	7	0.2
		1953	108	8
		1954	3	0.1
		1955	756	93
		1956	83	0.5
		1957	204	43
		1958	17	1
		1959	2,964	391
		1960	16	0.7
		1961	2,295	463
		1962	9	0.4
		1963	1,232	239
		1964	171	23
[2] Whale Pass Creek Southeastern Alaska	36,245	1961	2,887	684

Table 1. (Continued)

Stream	Area of spawning ground	Brood	Potential egg deposition per m^2.	Fry production per m^2.
	M^2.	Year	Number	Number
[2]Pleasant Bay Creek Southeastern Alaska	16,585	1961	4,248	529
[2]Disappearance Creek Southeastern Alaska	(17,658)	1961	1,750	296
		1962	2,027	198
		1963	4,442	421
		1964	3,309	363
[3]Hooknose Creek British Columbia	[4]6,273	1947	2,354	23
		1948	294	23
		1949	247	16
		1950	703	106
		1951	489	82
		1952	1,506	225
		1953	1,193	190
		1954	5,385	201
		1955	407	22
		1956	291	84
		1957	1,113	31
		1958	1,856	259
		1959	399	61
		1960	712	225
[5]McClinton Creek British Columbia	[4]35,130	1930	1,446	153
		1932	376	65
		1934	3,971	359
		1936	1,514	105
		1938	242	58
		1940	757	144

Table 1. (Continued)

Stream	Area of spawning ground	Brood	Potential egg deposition per m^2.	Fry production per m^2.
	M^2.	Year	Number	Number
[6]Karymaisky Spring Kamchatka	28,000	1943	[7]6,500	169
		1944	983	24
		1945	1,160	13
		1946	879	39
		1947	5,274	170
		1948	896	41
		1949	246	15
		1950	165	10

[1] Data on potential egg deposition and fry production through 1959 given by Merrell.(1962). Data subsequent to 1959 not previously published.

[2] Data from Wright (1964 and personal communication).

[3] Data on potential egg deposition and fry production from Hunter (1959) and Parker (1962).

[4] Data on spawning ground area from Wickett (1958).

[5] Data on potential egg deposition and fry production from Pritchard (1948).

[6] Data from Semko.

[7] Potential egg deposition calculated by assuming 2.2 percent fresh-water survival of chum salmon.

Table 2. Levels of fry production and associated potential egg deposition and freshwater survival

Range of fry production per m^2.	Observations	Potential egg deposition per m^2. Average	Potential egg deposition per m^2. Range	Average Total freshwater survival
Number	Number	Number	Number	Percent
Low Range				
0 - 100	37	729	7-6,507	7
High Range				
101 - 200	8	2,427	703-6,500	11
201 - 300	7	2,331	712-5,385	15
> 300	7	3,445	2,295-4,442	14

It is not known if different streams approach maximum production at similar levels of potential egg deposition; but streams appear to differ in their maximum fry production per m^2. The maximum number of fry observed in the seven streams listed in table 1 varied between 170 and 684 per m^2. of spawning ground.

Levels of fry production have failed to exceed 300 per m^2. in Hooknose Creek and Karymaisky Spring, despite very high levels of potential egg deposition. This may reflect one of 3 circumstances: (1) Hooknose Creek and Karymaisky Spring have a lower potential for producing fry than the other study streams. (2) Density-independent mortality prevented capacity or near capacity production. (3) Fry from higher levels of potential egg deposition were on a descending limb of a dome-shaped reproduction curve, and intermediate levels of potential egg deposition capable of producing larger numbers of fry were not observed.

It is not entirely clear from inspection of points relating number of fry produced per m^2. of spawning ground to potential egg deposition whether the freshwater production curve is dome-shaped or asymptotic. A dome-shaped curve provides a fairly good description of points relating fry production to potential egg deposition for Sashin Creek (fig. 4) and is somewhat descriptive of the points for Hooknose Creek (fig. 5). Fry production demonstrated an increasing trend at levels of potential egg deposition observed in McClinton and Disappearance Creeks and Karymaisky Spring (figs. 6, 7, and 8). Depending upon the assumptions one wishes to make, data for these three streams could be fitted with either a dome-shaped or an asymptotic curve.

It may be unwarranted to attach great significance to individual points plotted in figures 4 through 8, because an existing density-dependent relationship might well be obscured by density-independent mortality. Especially where observations are few at higher spawner densities, variability in density-independent mortality could cause an existing asymptotic relationship between fry production and potential egg deposition to appear dome-shaped.

Overpopulation of spawning grounds should be avoided regardless of whether the freshwater reproduction curve is asymptotic or dome-shaped. If the reproduction curve is asymptotic, very large numbers of spawners are required to produce minimum numbers of fry; but additional escapement beyond a level providing high utilization of the spawning ground will result in wastage from inefficient spawning. If the reproduction cuve is dome-shaped, there exists an additional danger from over-escapement. Not only will there be wastage of spawn, but future production will be impaired.

Overpopulation of spawning grounds occurs less frequently than underpopulation. If maximum fry production can occur with a potential egg deposition of 2,300 to 4,400 per m^2. of spawning ground, the desired number of pink salmon spawners in Sashin Creek would range between 33,000 and 66,000, assuming an equal sex ratio. Escapements to Sashin Creek exceeding 63,000 adult pink salmon have occurred twice in 31 years and escapements less than 33,000 have occurred 26 times in 31 years. In Hooknose Creek, pink and chum salmon spawners have provided fewer than 2,300 eggs per m^2. in 12 to 14 years. Examination of escapement estimates for other streams in Southeastern Alaska reveals a widespread tendency for

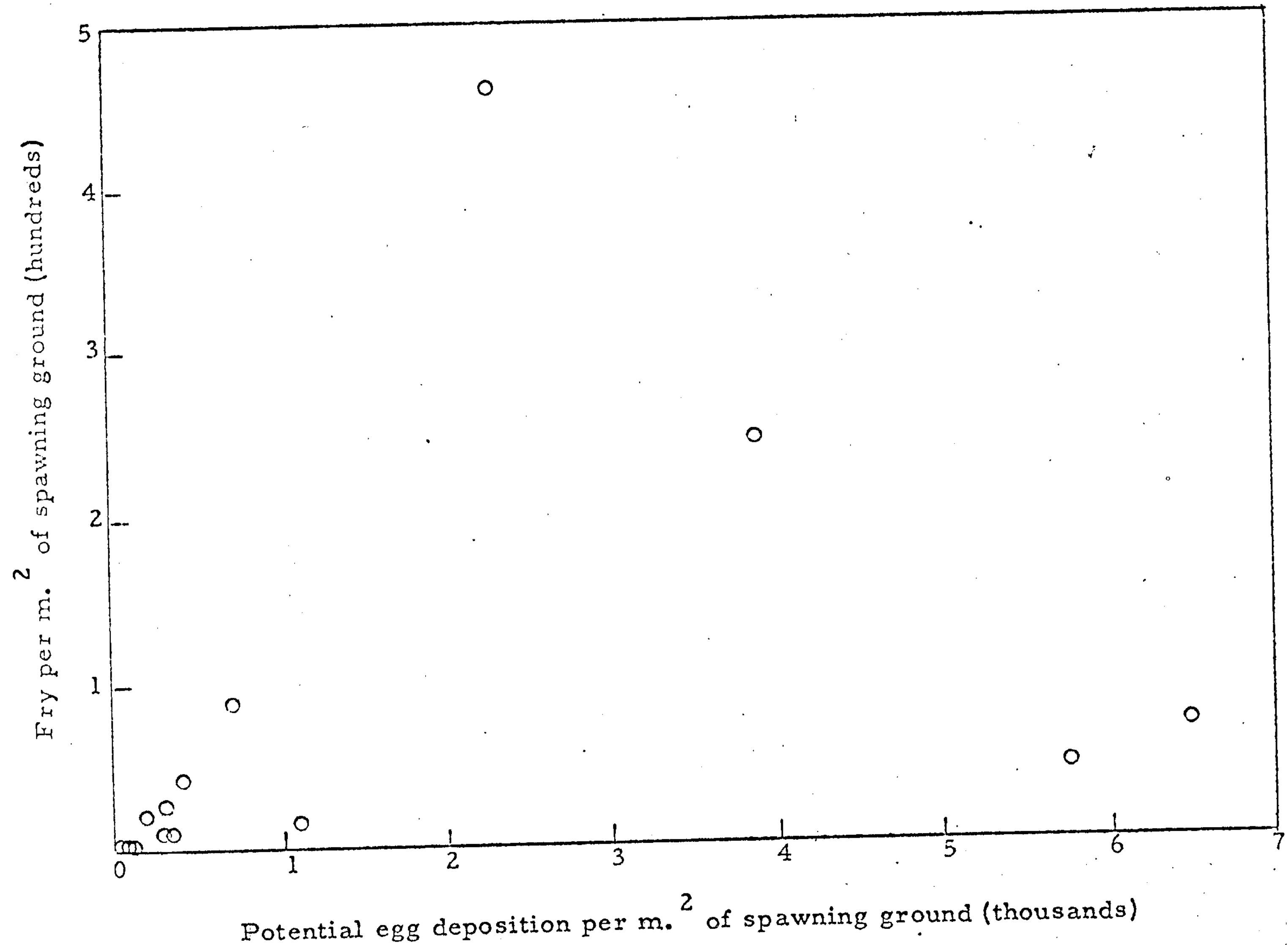

Figure 4. Reproduction of pink and chum salmon in Sashin Creek

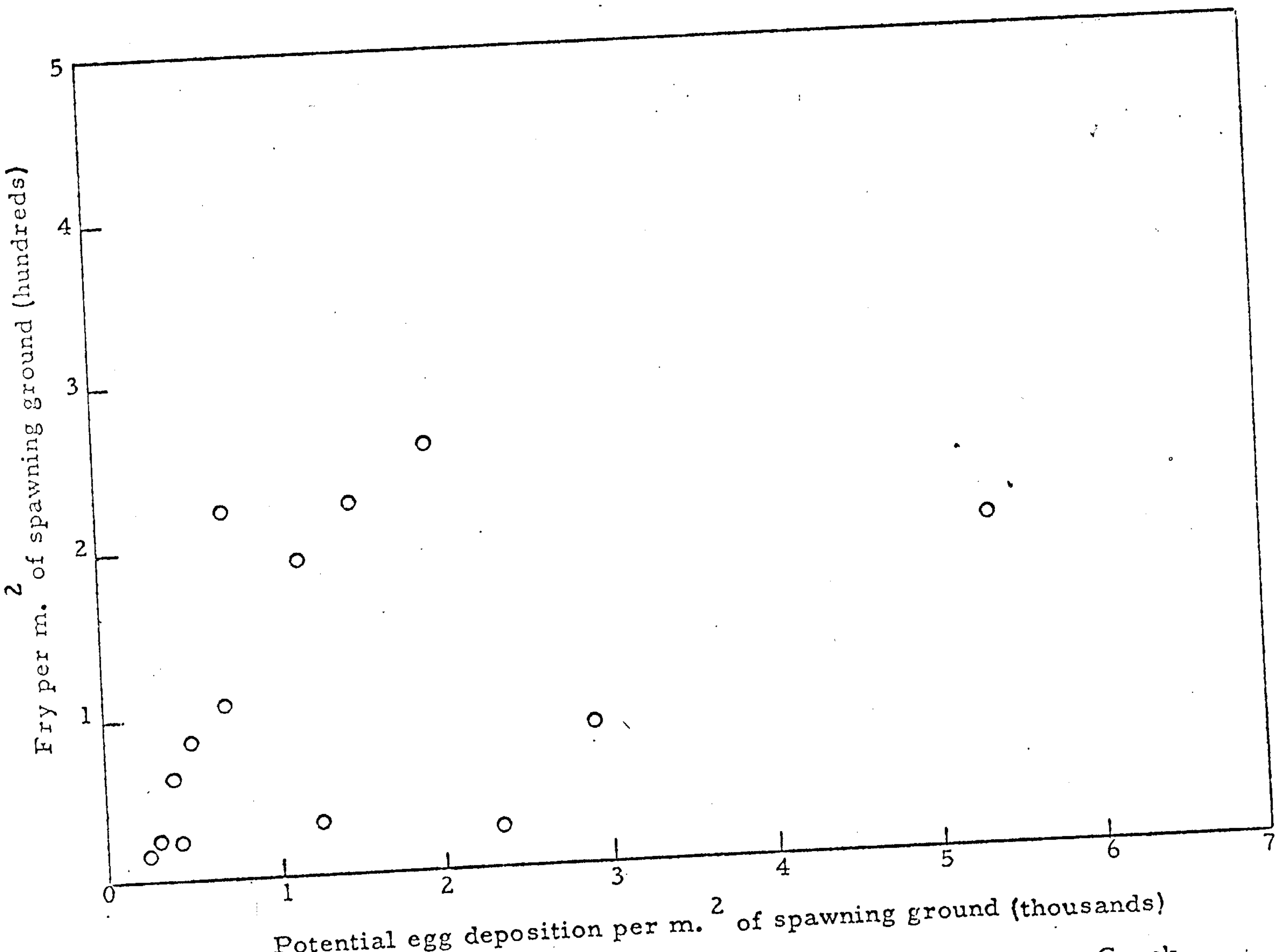

Figure 5. Reproduction of pink and chum salmon in Hooknose Creek

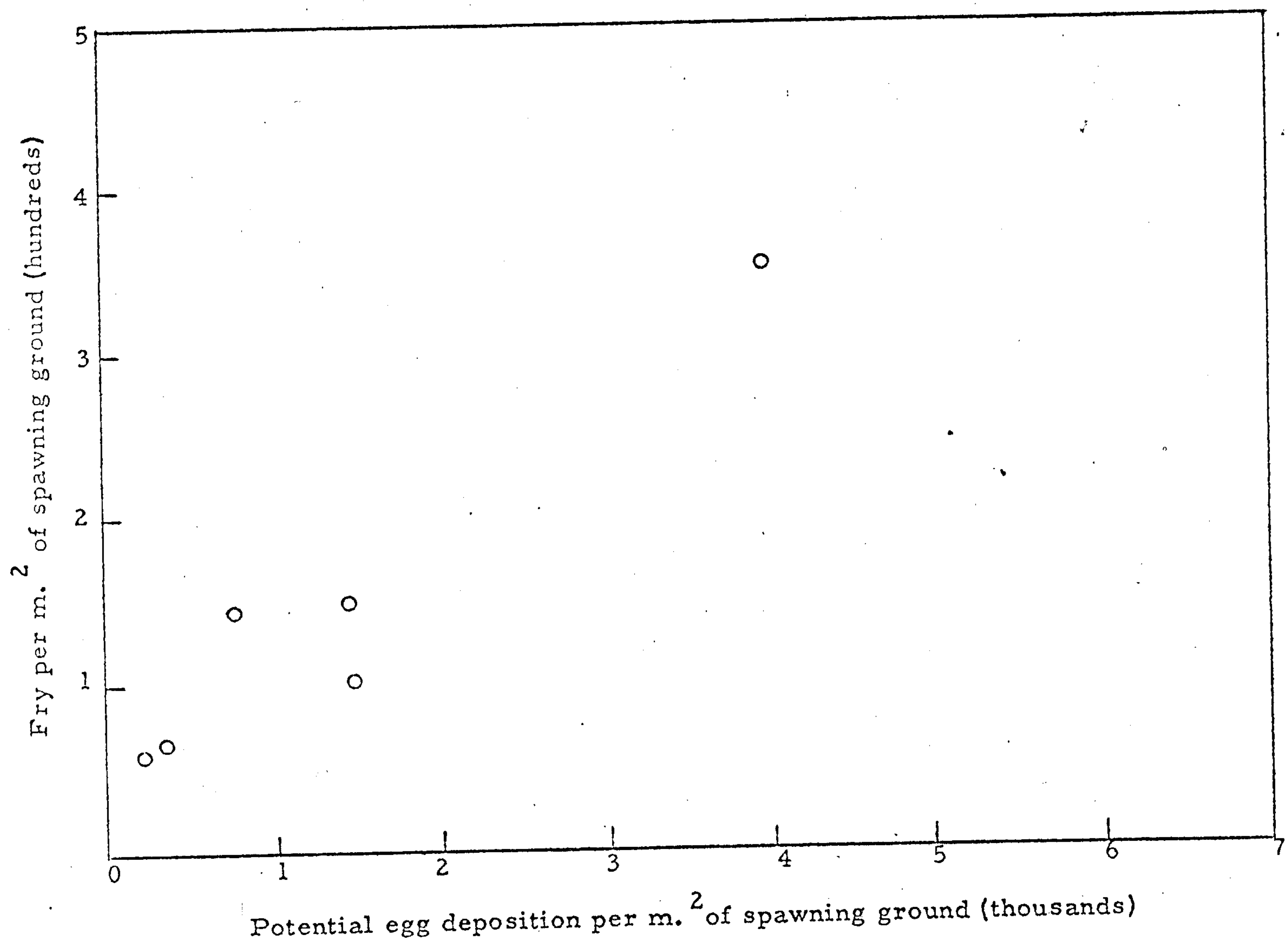

Figure 6. Reproduction of pink salmon in McClinton Creek

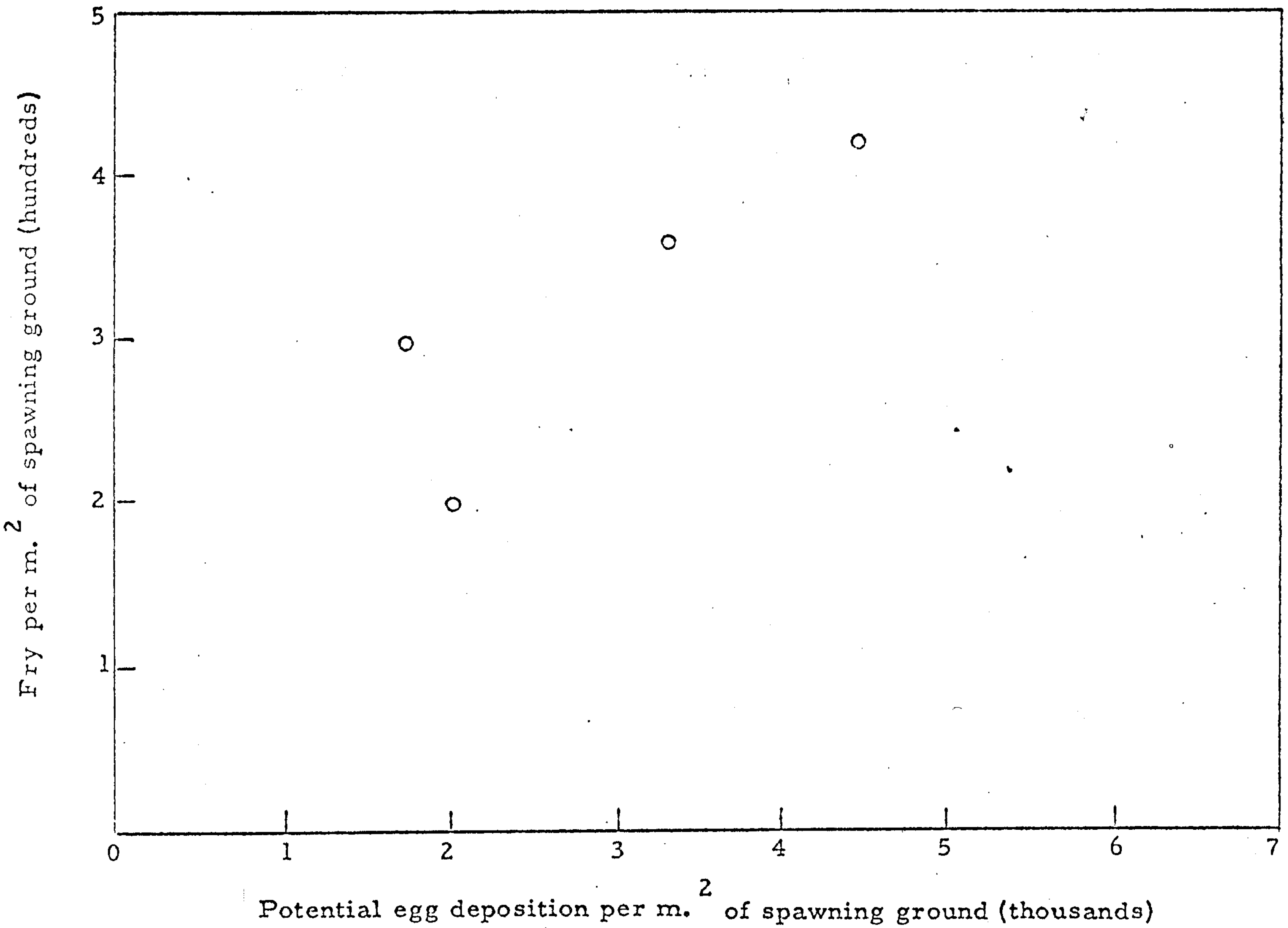

Figure 7. Reproduction of pink and chum salmon in Disappearance Creek.

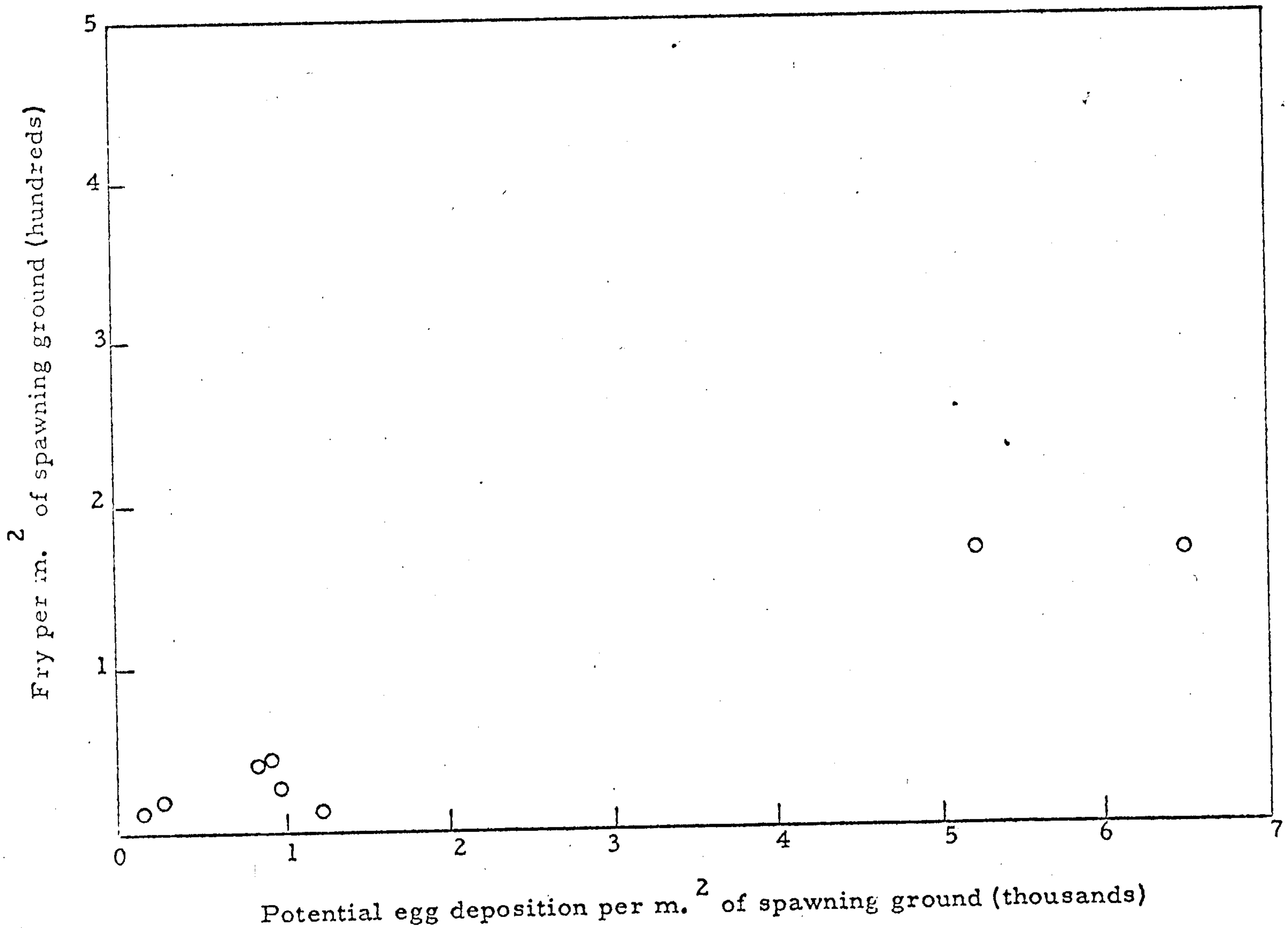

Figure 8. Reproduction of pink, chum, coho, and sockeye salmon in Karymaisky Spring

inadequate escapements of spawners. Wickett (1958) reports a similar circumstance for streams in British Columbia. Rehabilitation of depleted pink and chum salmon runs could most surely be facilitated, therefore, through closure of fishing grounds until adult escapements rebuild to satisfactory high levels.

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Remarks by McNeil at the Pink Salmon Workshop on

RANDOMNESS IN DISTRIBUTION OF PINK SALMON REDDS

Three general hypotheses about the distribution of redds within a spawning area are possible: (1) once a redd has been dug, there is decreased likelihood of further digging at the location (hypothesis of uniform dispersion); (2) redds are dug at random locations (hypothesis of random dispersion); and (3) once a redd has been dug, there is increased likelihood of further digging at the same location (hypothesis of contagious dispersion).

These hypotheses were tested in a 202 square meter study area in Lover's Cove Creek (Baranof Island) by burying a single table tennis ball 8 cm. deep in the gravel bed at 216 locations. The balls were marked to identify their locations of burial and were buoyant so they would rise to the surface should the bed be sufficiently disturbed. The study area was stocked with unspawned pink salmon, yielding an average density of 0.87 females per m^2. Balls released by the spawners were collected each day and reburied at their original locations. The first balls were collected and reburied September 11 and the last October 5. The experiment continued 25 days.

The number of occasions a location containing a ball had been dug by spawners was indexed by the number of times the ball had been released from the streambed. To obtain information on randomness in the distribution of redds, the observed number of locations from which balls had been released 0, 1, 2, ... times was compared with the expected number calculated from the Poisson and negative binomial probability distributions. The results are summarized below.

The pattern of release of balls from the Lover's Cove Creek study area indicates that dispersion of redds is contagious. This conclusion results from variance being greater than mean and good agreement between observed occurrence of balls released 0, 1, 2, ... times and the expected occurrence from the negative binomial distribution.

Observed occurrence of balls released from Lover's Cove Creek study area - 1, 2, 3, 4, 5, and > 5 times and the expected occurrence from the Poisson and negative binomial probability distributions.

Number of Releases	Observed Occurrence	Expected Occurrence Poisson dist.	Expected Occurrence Neg. Binom. dist.
0	116	104.4	113.2
1	59	75.9	64.8
2	29	27.6	25.6
3	10	6.7	8.7
4	0	1.2	2.7
5	2	0.2	0.8
> 5	0	0.0	0.3
	216	216.0	216.1

The mean number of releases per location is 0.73. The variance is 0.934.

DISCUSSION

Mr. Smith: If you assume density dependent factors operating, would it be better to use adult escapement against fry survival to get an expression for efficiency of spawning?

Dr. McNeil: In a sense they are equivalent - potential egg deposition is number of spawners times fecundity.

Mr. Smith: At Lakelse there were a billion eggs deposited by 1.3 million spawners. In another year we could get the same deposition with 25% fewer fish.

Dr. McNeil: When fish are less fecund they might also be smaller, less vigorous and dig up less area. If this relationship exists, potential egg deposition might be a better expression. If the relationship doesn't exist, perhaps we should compare numbers of spawners.

Dr. Bevan: May I pose a general question to the panel? Based on Dr. McNeil's comments I want to show another kind of curve. The sort of curve that I hope management people will think about. Let us take along the base line some increasing ability to know what optimum escapement is (Figure 1). Let us say that at 5 we really know what it is; we are not worried about any error; we know precisely how large an escapement to allow. For comparison, we can go back to 4 and say that here we have some fair estimates. Howard Smith talked about runs of this type. Somewhere between 0 and 1 we don't have any idea of optimum escapement at all and perhaps we don't even use the concept for management. Perhaps between 1 and 2 optimum escapement is defined as something probably less than the total run in a big year and something more than all of the run in a very poor year. I have the idea that Dr. McNeil was telling us that all of our fisheries should be somewhere above 3 and that our best estimate of optimum escapement is two fish per sq. m., one male and one female. The ordinate on my curve is the number of management agencies that have the level of ability to define optimum escapement as stated on the abscissa. My curve is a fictious one, of course.

My question is, what is the true curve? If Bill McNeil is right, we ought to have a curve like the one with a solid line in Figure 1. We should never manage an area with less information than a preliminary estimate of 2 fish per sq. m.

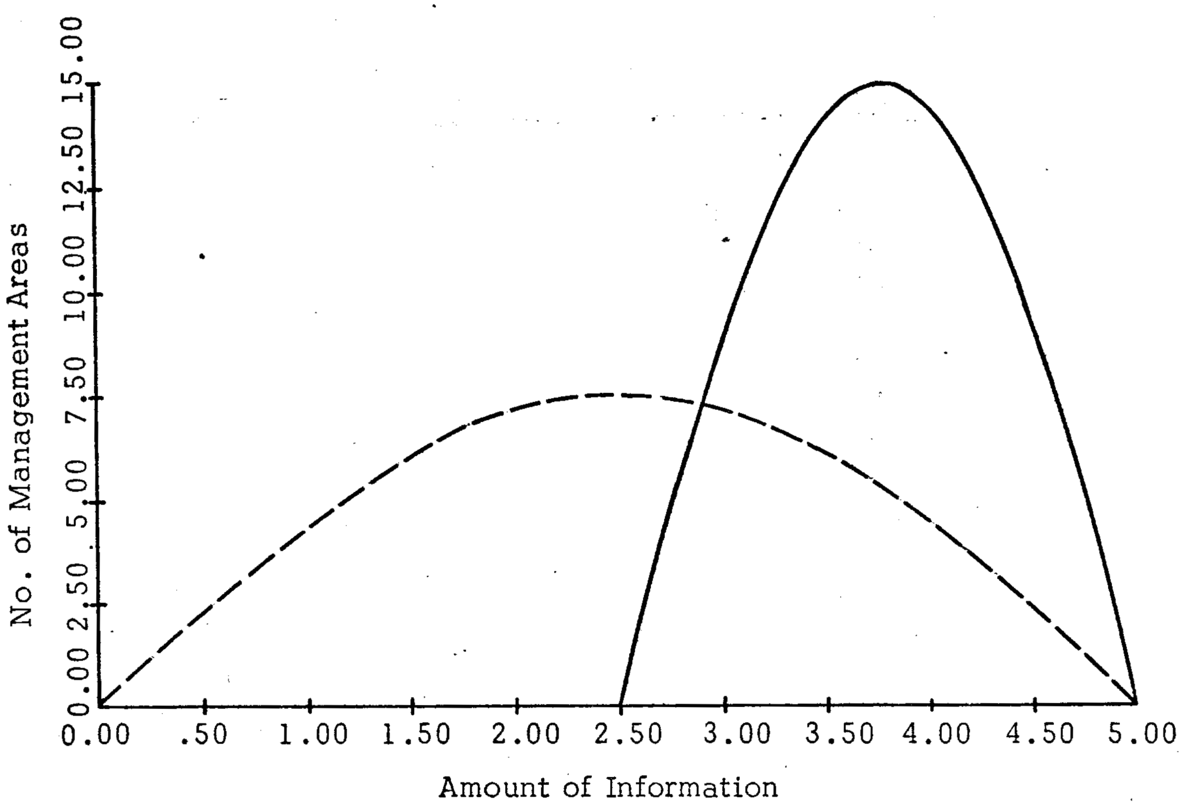

Figure 1. Regulation for Optimum Escapement

A POSSIBLE APPROACH TO DETERMINE THE ESTIMATED OPTIMUM ESCAPEMENT LEVEL OF PRINCE WILLIAM SOUND PINK SALMON STOCKS

Robert S. Roys, Alaska Department of Fish and Game, Cordova

INTRODUCTION

The purpose of this paper is to present a brief analysis of three types of interrelated data collected annually in Prince William Sound that may yield a usable optimum escapement estimate in the very near future. These three categories of data are: (1) estimated indexed pink escapements and returning runs, (2) estimated indexed pink escapements and resultant pink alevin indices, and (3) pink alevin indices and resultant returning runs.

METHODS

Escapement Estimates

Timed aerial and ground surveys of pink salmon escapements in 80 streams of Prince William Sound have been conducted since 1952 by the Fisheries Research Institute (1952-1958) and the Alaska Department of Fish and Game (1960-1965). Total escapement for these systems is calculated by dividing summed weekly estimates for each stream by a stream life factor of 2.5 weeks or in some cases 4.0 weeks. (Derived from tagging 1957, 1958 and 1961). Calculated escapements from these 80 index streams annually represent approximately 75 percent of the total calculated escapement of 300 streams in Prince William Sound. Therefore, by confining our observations to these 80 streams we have a fair indication of the relative magnitude of escapements from year to year by timing (early, middle, or late run category) and by distribution within the streams (intertidal, immediately above high tide or in the headwaters). An average of 75 percent of the even-year spawners utilize the intertidal zone (range 70-77%). The remainder spawn immediately above high tide (there are a few individual exceptions). This is in contrast to the behavior of odd-year spawners that tend to utilize the freshwater zones more heavily than the intertidal zones. (Range from 35 to 57% intertidal). Odd-year freshwater spawners in the majority of systems tend to migrate further upstream and therefore utilize more riffle area than even-year spawners. This is particularly noticeable in the Eastern and Southeastern districts of Prince William Sound.

Alevin Sampling

Thus far, four relatively accurate forecasts of pink salmon runs destined for Prince William Sound have been published since 1962. These forecasts have chiefly been based on an alevin index that has been derived from sampling 30 to 40 streams each spring and determining mean abundance of pink alevins per unit area. Samples (using hydraulic excavator and collecting net) are obtained from intertidal and freshwater zones and by timing category (early, middle or late run). Returning runs are estimated by summing catches and calculated total escapement (Figure 1).

DISCUSSION

From an optimum escapement standpoint then, it should be of interest to analyze data from two sources: (1) escapements and returns, and (2) escapements and subsequent alevin indices. For the purposes of this brief analysis we will assume that the percent of intertidal or freshwater pink salmon in any given estimated total return (catch and escapement) are in the same percentages as the percentage of spawners utilizing the intertidal or freshwater areas. For example if 75 percent of the escapement was intertidal then 75 percent of the total estimated run that year would be considered intertidal fish.

Escapement Index to Return

The two graphs in Figure 2 show the developing relationships between intertidal and freshwater zone indexed escapement and assumed intertidal return and assumed freshwater zone return for odd-and even-year cycles. Thus far in Prince William Sound it appears the spawner-return

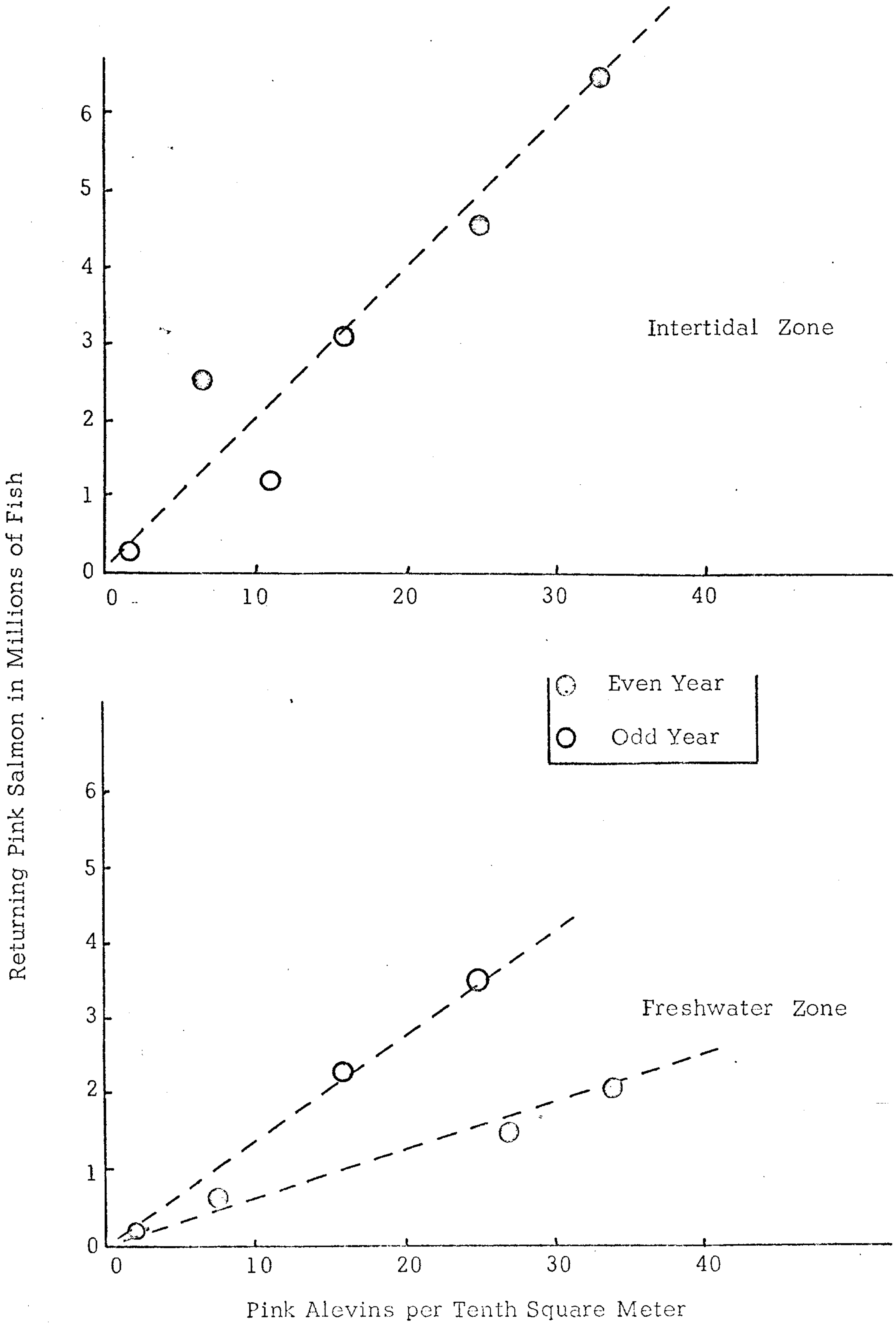

Figure 1. Relationship of pink alevins to return for the intertidal and freshwater zones of Prince William Sound. 1958 to 1964.

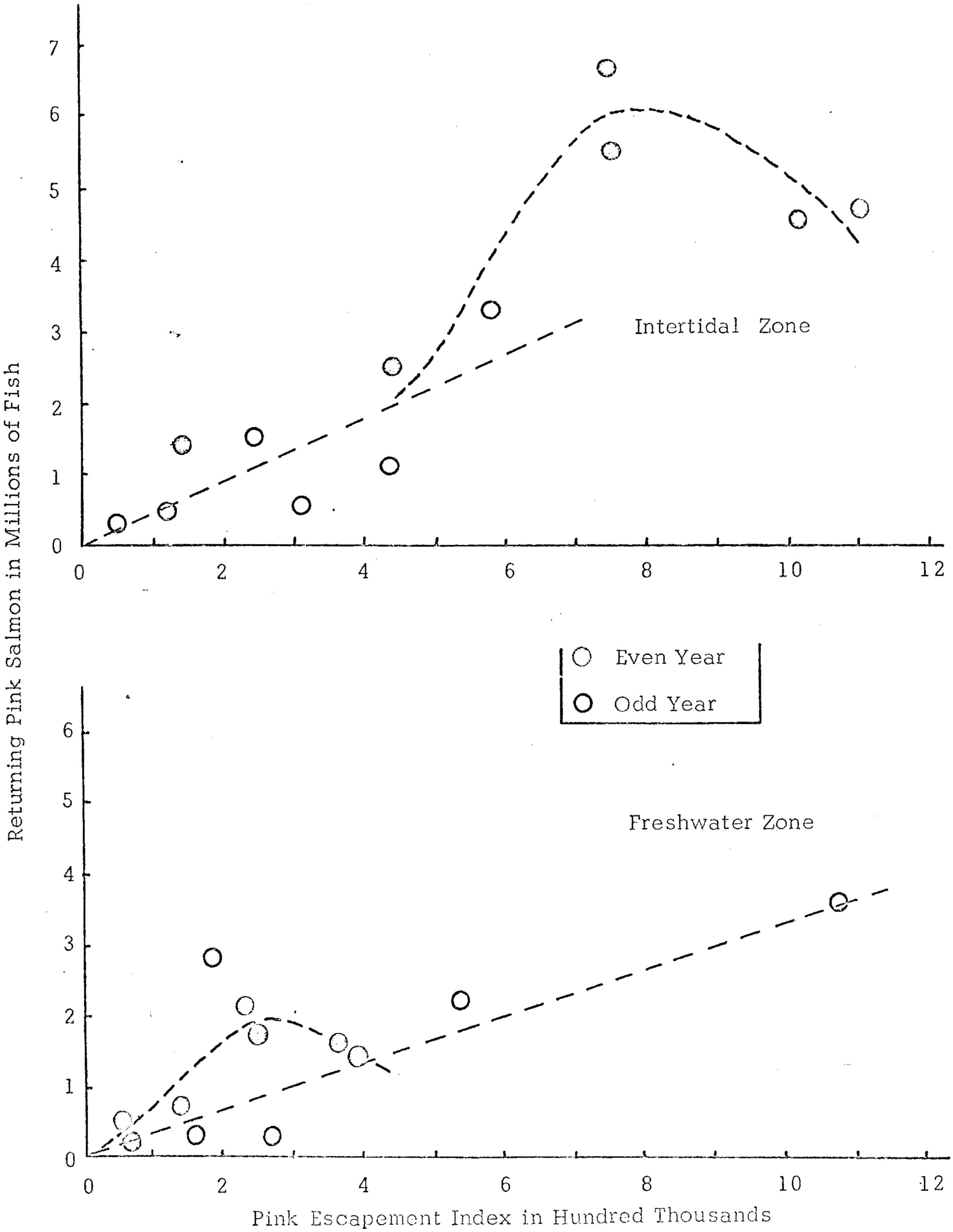

Figure 2. Relationship of estimated indexed pink salmon escapement and return for the intertidal and freshwater zones of Prince William Sound. 1952.to 1965.

relationship for the even-year cycle, intertidal and freshwater zone is developing in a curvilinear fashion. (Lines were fitted by eye). However, the odd-year cycle, intertidal and freshwater spawner return relationship is developing in a linear fashion. We need several more years of data for substantiation and this is particularly necessary since the spawning distribution changes caused by the earthquake may alter these developing relationships. However, if these trends continue to develop as briefly shown then we have received more estimated (intertidal and freshwater) spawners in the Sound for the even-year cycle than needed but have not yet arrived at this range for the odd-year cycle in either the intertidal or freshwater zones of the environment.

Escapement and Subsequent Alevin Index Relationship

In Figure 3 are shown the developing relationships between estimated indexed escapements and resultant alevin indices. (Lines fitted by eye). As in the escapement to return relationship, the escapement to alevin index relationship is developing similarly. The even-year intertidal and freshwater zones are developing as a curvilinear relationship and the odd-year relationship thus far is linear or nearly so. (Spring sampling in 1966 has been added).

CONCLUSION

A more detailed examination of similar data for a single district or district groups and by timing category (early, middle or late) exhibits similar relationships developing as shown by Figures 1, 2 and 3. It is hoped in the very near future that estimated indexed escapement goals may be derived for districts and by timing category and that these estimates will be usable for management.

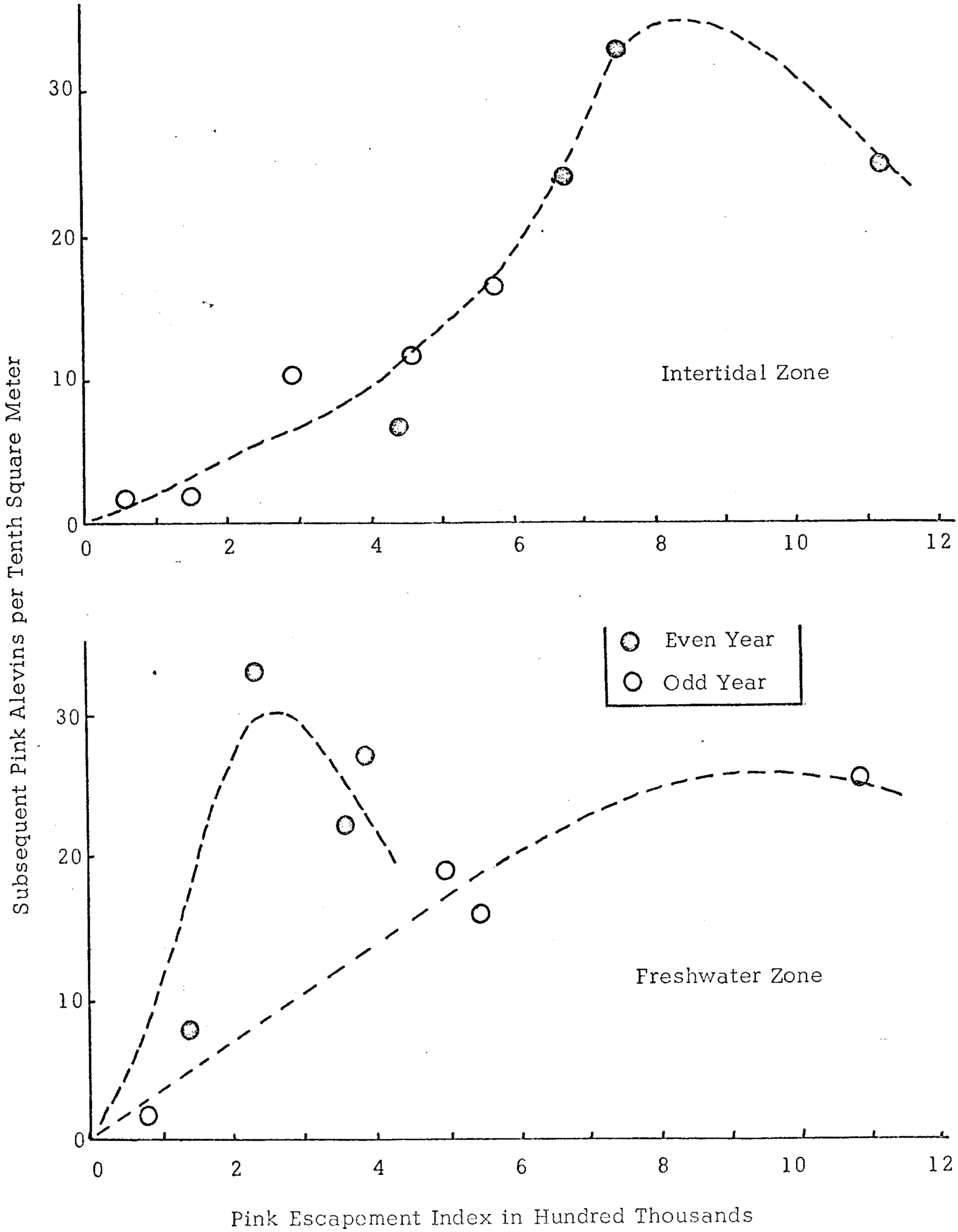

Figure 3. Relationship of estimated indexed pink salmon escapement and subsequent alevin densities for the intertidal and freshwater zones of Prince William Sound. 1957 to 1966.

SONAR SALMON COUNTER

Allen S. Davis, Alaska Department of Fish and Game, Homer

The Bendix-Pacific Division of the Bendix Corporation was contracted by the Alaska Department of Fish and Game to develop a sonar salmon counter for use in glacial waters. A signal is transmitted at 200 KC. When reflected from stationary objects such as rocks, the resulting return signal is received at the same frequency. Any signals received at higher or lower frequencies are reflected from moving objects and activate the numerical counter. The moving air bladder of the salmon is, in this instance, the reflector.

Initial testing was conducted for three weeks at a counting tower site on the Kvichak River in Bristol Bay, during the early stages of the red salmon run. The number of salmon registered by the counter was 255,465 and the number visually estimated was 263,508.

A second test, conducted in the glacial Kenai River was unsatisfactory because of the occurrence of single counts at 90 second intervals. The unit was then moved to the clear water Russian River. Here passing salmon were distinguished from the 90 second interval background counts because once again the salmon could be visually observed. The number of salmon registered by the counter was 2,380 and the number visually estimated was 1,637.

The effective range of the counting device was 25 feet horizontally and 9 feet vertically. The counting rate was 15,000 fish per hour. Fish other than salmon and wind ripples also activate the counter and at present species differentiation is not possible. In spite of these drawbacks I feel that with refinements of the mechanical processes we will have a usable tool.

Estimated cost of production counters in lots of one hundred is $1100 to $1500 each. We are presently negotiating with Bendix to obtain counters for further testing in the glacial Kenai and Kasilof Rivers and some clear water streams in Bristol Bay.

DISCUSSION

Mr. Martin: The Pfleuger depth finder has been on the market for 4-5 years and it operates on a similar principle - its called Doppler Sonar where the sum or difference of the outgoing and returning signal is available. It costs $60. Doppler Sonar is superior to normal sonar in that you can aim it at a beach or other background. The background echo is cancelled out and the only thing registered is the movement of fish.

Mr. Jewell: We tried the Pfleuger in a beach seining operation in a river. It registered fish, but we had no idea how many. Its a handy tool, but it does have drawbacks.

Mr. Noerenberg: The sonar device that Al Davis talked about will cost the Alaska Department of Fish and Game about $100,000 to develop. It will have wide application up and down the coast because of the need for refinement in obtaining estimates of escapements. I think we should think about spreading the cost of development of these types of tools among several agencies if possible.

INTRODUCTORY REMARKS FOR PANEL ON PINK SALMON FORECASTING

R. A. Fredin, Bureau of Commercial Fisheries, Seattle

I might review, at the outset, two experiences indicative of my qualifications for leader of the panel on forecasting of pink salmon runs. About a year ago I worked with a number of my colleagues along the coast, on a forecast of the size of the sockeye run to Bristol Bay in 1965. We came up with a forecast for a run of about 27 million fish. As it turned out, the run was more like 60 million fish. It has since been pointed out to me that our forecast was off by one hundred percent. Actually, one can look at it another way: the forecast was only about 50 percent off. It depends upon the standard used.

My other qualification is that several months ago I made a forecast--that is, I advised Chuck Meacham--that there would be seven speakers on the panel. The figure looked pretty good until Mike Shepard informed me that certain developments made it impossible for him to participate. Then Roger Pearson from the Seattle Biological Laboratory offered to contribute to the panel. My forecast turned out to be pretty good.

So much for qualifications.

I do not think there is any particular need for my discussing in detail the importance of forecasting salmon runs--runs of pink, or other species of salmon. I am sure that the needs of the management agencies, fishing industry and governments for accurate forecasts are familiar to all of you. For example, yesterday we heard a number of speakers talk on optimum escapement. Determination of optimum escapement is one thing; achievement of such a goal by the management agency is another thing. Clearly, an accurate forecast is a prerequisite to achievement of optimum escapement.

We have an impressive array of speakers. Our panel is arranged in the order of the timing of forecasts, starting with indices of abundance or pre-emergent fry and ending with indices which might be used a few weeks before the entry of the runs into the fisheries. Roger Pearson's talk will not deal with forecast indices per se, but with racial characteristics which might be useful for forecasting pink salmon runs from estuarial or marine indices of abundance.

We will start off our panel, then, with Ted Hoffman who will tell us about the use of indices of abundance of pre-emergent fry for forecasting pink salmon runs in Alaska.

FORECASTING PINK SALMON RUNS

Theodore C. Hoffman, Alaska Department of Fish and Game, Juneau

INTRODUCTION

The pink salmon forecast research program of the Alaska Department of Fish and Game began in Prince William Sound in 1961 and was expanded to Southeastern, Kodiak and Cook Inlet in 1963. In all areas a relationship between a representative early stage abundance (in this case abundance of pre-emergent fry) and return runs is assumed. If this assumption is incorrect it will be difficult to predict the return from a pre-emergent fry index.

In Prince William Sound a series of data on this relationship is available since 1961 from the Alaska Department of Fish and Game and previous data are also available from the Bureau of Commercial Fisheries on the abundance of pre-emergent fry, which so far has proven to be a reliable index in predicting return runs to that area. In Southeastern, Kodiak and Cook Inlet, sufficient pre-emergent fry data are not yet available to establish a return relationship with fry abundance; however, attempts are being made to utilize existing information for prediction purposes.

The major effort of these State programs at the present time is expended in the freshwater environment with estuarine fry sampling largely limited to Prince William Sound. Some initial estuary work is also being conducted in Southeastern.

The primary objective of the state's pink salmon research program is concerned with forecast with the exception of a cooperative effort in conjunction with the Forest Service relative to land use and salmon freshwater habitat.

The standard tool used in all areas for pre-emergent sampling is the hydraulic sampler developed by Fisheries Research Institute and used extensively in the Effects of Logging Program. Essentially we are excavating random plots in important and accessible spawning streams to give year to year comparisons of fry abundance. This is done just prior to fry emergence after the major causes of freshwater mortality have passed.

Fry abundance is related to both catch and escapement data provided by the management biologists in the Commercial Fisheries Division in an attempt to reconstruct a total run picture. Although all of our programs have certain things in common, the differing logistical problems in the respective areas have given rise to somewhat different approaches from a sampling standpoint.

PRE-EMERGENT FRY SAMPLING IN SOUTHEAST ALASKA

Background

The forecast program in Southeastern Alaska began in 1963. Although exploratory work began in 1962, no substantial fry excavation was accomplished in that year. Only ten streams were sampled in 1962. The summer months of 1963 were expended in surveying streams in preparation for spring 1964 fry sampling. The 1963 layout work did not provide adequate area stream distribution and the following summer's survey was concerned with filling these gaps. There are still some weak spots in coverage in the mainland areas of Southeastern, with a lack of coverage in Portland and Behm Canals. This is primarily due to the nature of the mainland streams with their difficulty of access.

To date, with some minor exceptions, the areas which are sampled are located in the lower portions of the streams where it is possible to have tide water access and the areas selected have had to conform to the restrictions of the sampling equipment.

Method

The basic tool in use in all of the fry work conducted by the Department is the hydraulic sampler. Essentially the sampling program in Southeastern is devised to provide estimates of pre-emergent fry abundance per unit area of spawning bed, or to provide estimates of total fry yield from the sampling stratum. All areas previously inspected and surveyed for future sampling are considered as the basic stratum. These areas are further sub-divided into sampling units or one-tenth portions of units (a unit for this discussion is 43,560 sq. ft. or 1 acre). The amount of sampling effort expended in any one unit is 40 two-square foot samples or 80 square feet excavated for any one unit sampled. In any one year the number of units and tenths of units are selected randomly from the total units and tenths of units available for sampling. The magnitude of the sampling effort is contingent upon the money available in any one year. So far about 3,000 samples have been taken yearly and this includes several streams which are sampled every year because of a specific need. The effort allocated to one unit (40 samples) is randomly distributed in that area in eight clusters of five samples, mainly to save time; therefore, in a sense we have a cluster sample within a cluster sample. This type of sampling allows us to treat the data in a number of different ways. For example, any number of geographic comparisons can be made, provided sufficient samples are available within the areas of interest. Another comparison which might be useful would be between production in early, middle or late run streams. This method also provides for the continued inclusion of additional spawning area or the exclusion of areas without seriously effecting past information as well as an increase or decrease of sampling effort dictated by financing in any one year.

With the accumulation of pre-emergent fry data, a discriminant analysis could possibly yield selection of those streams, which could satisfy as predictors. If this analysis fails, the option is still available for the coverage of a significant portion of the producing area available to pink salmon in Southeastern for brood production-return run comparisons. To date, neither of these conditions have been satisfied because in one situation the program has not been operational long enough and in the other the basic stratum is not at this time significantly large in relationship to the total spawning area available. In Prince William Sound, where the prediction program has been successful for several years, about 40 percent of the producing area is included in the sample, whereas in Southeastern we may be covering only about 10 percent of the area.

In the course of the last two years we have changed the components of the sampling gear considerably with the exception of the pump - which has been a Fairway-Montgomery Ward pump with a B and S power plant and an output of approximately 7,000 gph. First, we mounted the pump in an aluminum punt. Then we tried a combination of tripod mount with the pump mounted on a packboard and now we are planning on adopting a complete back pack operation with the pump to be operated on the back of the individual who does the pumping. The Homelite pump mounted on the packboard has a 4200 gph discharge and because there was some doubt in our minds as to whether it would be as efficient as pumps previously used, an efficiency test was run comparing it with a Homelite with an output of 9,000 gph. There was no difference in efficiency regardless of the type of area sampled. We compared the two pumps in both rubble type and more uniform smaller gravel bottom.

Discussion

A brief comparison of fry densities observed in 1964 with those in 1965 reveals little if any significant difference as follows:

Category	Mean live fry plus live eggs-1964	Mean live fry plus live eggs-1965
All streams sampled included	18.7	16.5
Only random streams included	19.9	19.6
Streams repeated 1964-65	19.4	20.8
Streams from same base	18.7	20.5
N of Frederick Sound - All	22.0	24.1
S of Frederick Sound - All	16.5	12.7
Only random N of Frederick Sound	22.1	23.1
Only random S of Frederick Sound	16.4	15.1

The lack of difference in fry densities observed in 1964 and 1965 when compared with the large difference in the brood year escapements

(1,516,200 and 467,700 - Juneau area only) leads me to suspect the validity of the levels of fry observed.

Although one should not place great weight on escapement, you cannot deny that the potential is certainly different for the two years. One must also consider that the 1961 escapement which produced the 1963 run was in the magnitude of 873,000 (one district again). It should also be pointed out that the differences in the areas south of Frederick Sound were also comparable for 1964 and 1965 sampling.

It is my feeling that our downstream sampling must be tied in with sampling in those areas which we are not presently reaching from the intertidal zones. It appears from limited distribution information available, that very different escapement levels produce similar production levels in the lower stream areas, primarily because low levels of escapement result in similar numbers of spawners in these areas as are found in high levels of escapement with the primary difference being that higher level escapements have greater distribution within the streams. Upstream area sample coverage was planned to be included with the 1965 effort; however, lack of funds delayed such coverage until this coming spring. We hope that with the addition of upstream coverage and the projection of the downstream areas further upstream made possible with the use of lighter sampling equipment a more representative sampling can be attained. It is possible that the present sample is satisfactory; however some time must pass before this can be evaluated.

DISCUSSION

Mr. Junge: Your choice of streams from year to year is random, rather than index type?

Mr. Hoffman: That is correct.

Mr. Junge: Why do you feel this is better than using index streams?

Mr. Hoffman: With the random sampling scheme, we attain more flexibility, which we need in Southeastern Alaska where we have a large area to cover and a large amount of spawning to check on. During the first and second year, we duplicated about 80 percent of the streams and 20 percent were new streams.

Dr. McNeil: There are around 1,100 pink salmon spawning streams in Southeast Alaska, and I don't think you would get a representative sample on an index basis. What is the total area included in your sampling program?

Mr. Hoffman: More than 100 acres.

Mr. Noerenberg: We are using index streams in Kodiak Island and Prince William Sound. In the latter area, 90 percent of the escapement in 1960 occurred in 110 out of a total of 300 streams. We decided to cover all the major spawning streams. With so many more streams, there is much more of a problem sampling in Southeast Alaska.

Mr. Johnston: When we selected these streams, we picked the most productive.

Mr. Walker: What do you mean most productive? Did you select the streams because they looked good?

Mr. Johnston: No, selection was based on past records of production. Streams must also be accessible.

Mr. Walker: I think your samples are large; therefore, your variance and efficiency of recovery are different from ours. In a few isolated streams in British Columbia, we got tremendous differences in efficiency of recovery. In sand and gravel streambed composition, we got what we considered a high rate of recovery; in steeper gradient streams where there is less sand and more boulders, recovery appeared to go down, and in a spawning channel with no sand we got no recovery. The probe appeared to force alevins into the many interspaces. Where we sample a single stream, I think we must carefully examine efficiency of the equipment. In a much larger program, such as you have, I'm sure these differences even out.

USE OF THE TOW NET IN FORECASTING RUNS OF PINK SALMON TO KODIAK ISLAND, ALASKA

Richard W. Tyler, Fisheries Research Institute, Seattle

One of the goals of research by the Fisheries Research Institute, University of Washington, is to forecast Kodiak Island pink salmon runs one year in advance. These forecasts are derived from estimates of the numbers of juvenile pinks in estuaries as determined by surface trawl nets. An important assumption inherent in the method is that the numbers of young salmon headed seaward after having spent a month or two in salt water will be relative to the numbers returning as adults a year later. The 1965 spawning runs to Kodiak Island supported this assumption and gave evidence that our technique of sampling young pink salmon furnished an accurate indication of the size of the 1964 seaward migration.

The surveys have been conducted since 1963 in Alitak and Uganik Bays and since 1964 in Uyak Bay, and separate forecasts are made for each bay. If over a period of years our forecasts for these areas prove reliable and the sampling gear and methods appear adequate, then forecasts will be made for most if not all of the Kodiak Island management areas.

A variety of tow nets and trawls have been used in Alaskan studies to index the abundance of juvenile pink salmon, but have been abandoned because insufficient numbers of young pinks were caught. In 1960, a tow net was successfully used in indexing the abundance of sockeye salmon smolts in Bristol Bay lakes, and it was hoped that a net could be used similarly for young pink salmon in salt water.

Initial Tests

In 1962, an initial test of a tow net was made by the Fisheries Research Institute in Alitak Bay, Kodiak Island. The results were promising but indicated that young pinks were readily available in the bay only during a specific period in their growth: after they had moved away from the shorelines (when they were about 50 mm[1]) and until they became proficient at avoiding the net (when they measured about 125 mm).

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[1] Measured from tip of snout to tail fork.

Subsequent studies in Puget Sound have shown that the period of availability varies between areas depending on the manner of entry of young pinks into salt water. Availability of these fish at lengths between 50 and 125 mm is largely true in areas where they enter the heads of bays and fiords through clear streams. In such areas the young pinks remain along the shoreline for a month or two. Conversely, where their entry is through turbid streams or through rivers draining abruptly into the bay or ocean, the young pinks proceed directly to offshore waters and are then readily available to the tow net.

After the initial testing in 1962, the net was rescaled in order to cover a greater surface area. Its width was increased to 20 ft., its depth to 10 ft., and the top leading section was cut back to reduce overhead shadow at the entrance (Figure 1).

Tests of Gear and Technique, 1963

The first successful attempt to index numbers of juvenile pink salmon by use of the Kodiak trawl was made in 1963 in Alitak and Uganik Bays. Replicate surveys of both areas during July and August proved the results were reproducible.

To establish the indices, a series of cross-bay transects was outlined covering all parts of the bays from head to mouth. Tows were standard ized at 10 min. (a towing distance of about 1/2 mile) and were spaced from 1/4 to 1/2 miles apart. Alitak Bay, which together with its tributary bays encompasses an area of 135 miles^2, was sampled in 75 tows during a 5-day period. Catches ranged from 0 to 4,138 pinks per haul.

Tests were made to determine the diel variation in catches and the limitations diel variation would impose on townetting. The catch rate of the tow net on pink and chum salmon fingerlings was found to decrease during daytime towing after the fish had grown to a mean length of approximately 75 mm. This was determined by a series of repeated tow-net hauls made during a 24-hour period: five 10 min. hauls every 3 hours. The mean catch values of these 5-haul groups varied from 56.2 to 267.0 pinks per haul (Figure 2).

Analysis of these data has failed to show a significant daytime-

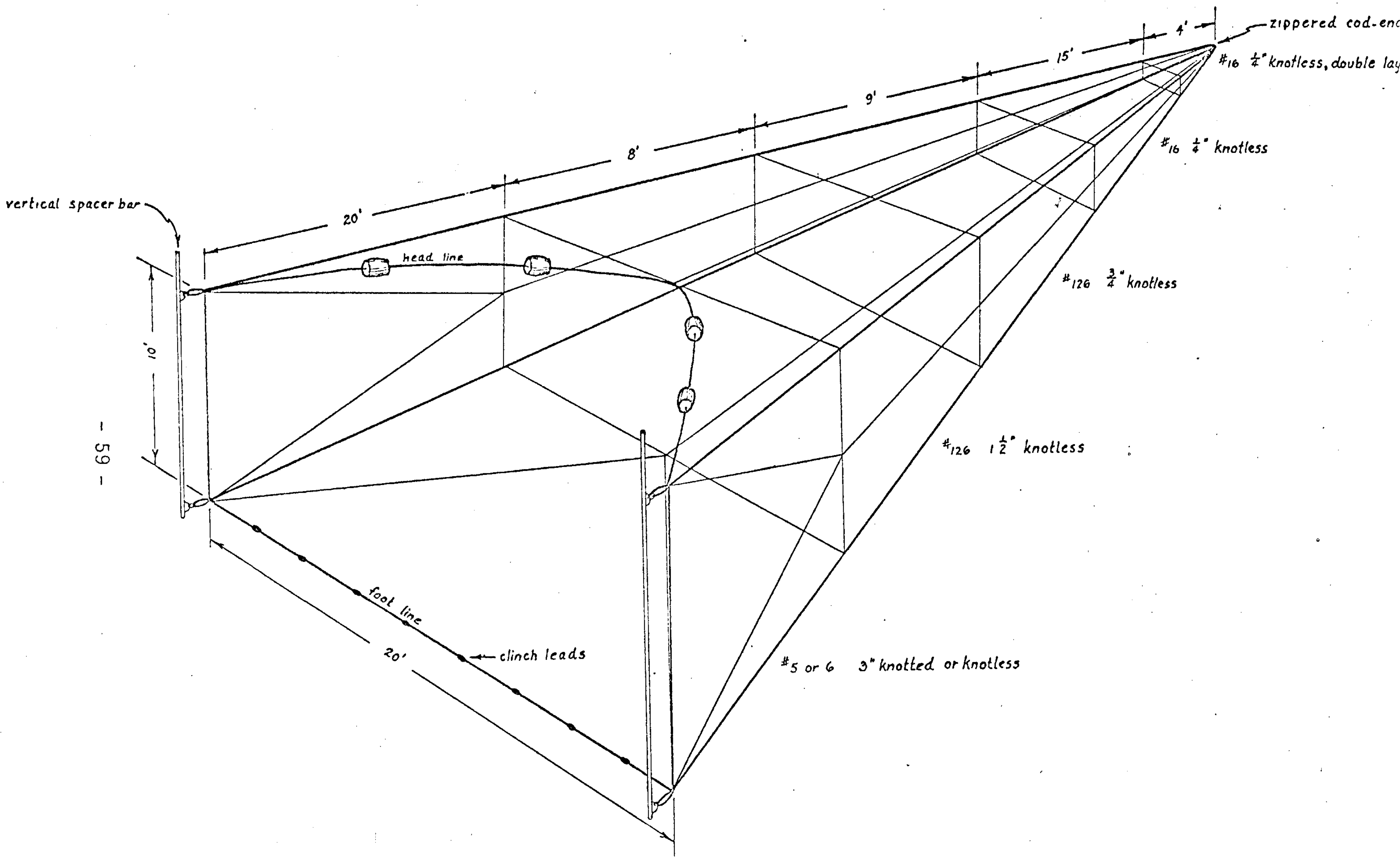


Figure 1. Design of the Kodiak trawl net.

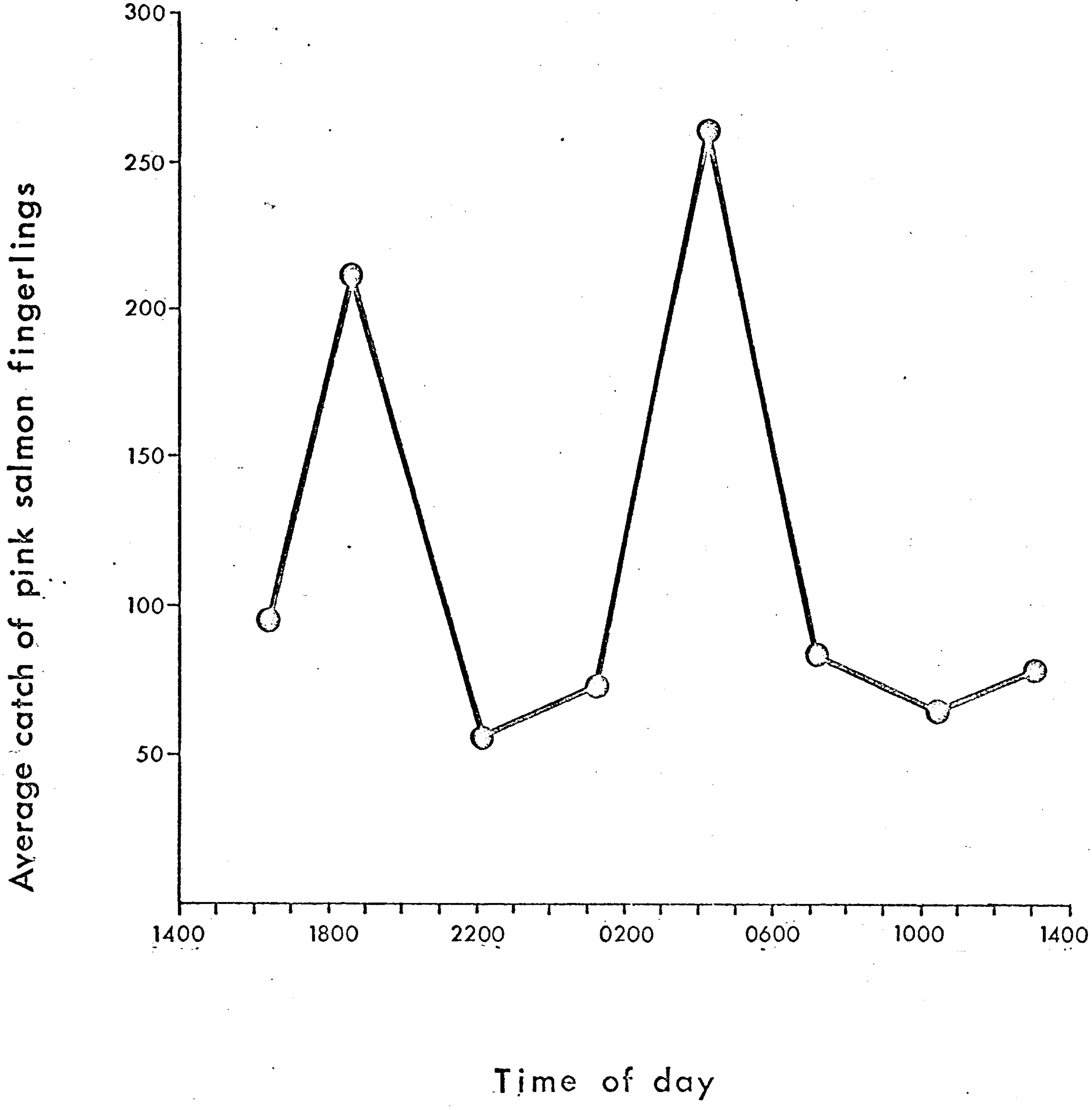


Figure 2. Diel variation in tow net catches of pink salmon fingerlings from Olga Bay, July 27 - 28, 1963.

nighttime difference in the total numbers of juvenile pink salmon caught but has demonstrated that pinks larger than 80 mm were more predominant in the nighttime catches between the hours of 2140 and 0200 (Figure 3). This difference is significant by chi-square test at the 1 percent confidence level. Logically, the nighttime catches should have been larger since they included all sizes of pinks caught during daytime as well as some which were not. However, the variability of the catches apparently was sufficient to mask such a relatively small difference. The mean length of pinks from the nighttime catches was 77.94 mm, and from the daytime catches 75.15 mm. The larger catches from the 1900-hour and 0400-hour samplings, as shown in Figure 2, cannot be explained in view of present information about environmental factors.

For comparison the catches of chum fingerlings during the same series of hauls were examined; large differences were readily apparent in both the catches and the length frequencies (Figures 4 and 5). We believe that the difference in catches was primarily due to the larger size of the chums rather than to behavioral differences between the species. The mean length of chums from the nighttime catches was 90.55, and from the daytime catches 79.72 mm.

Additional information on diel variation in catches was obtained in Uganik Bay during August, 1963. Pink salmon fingerlings were larger than in the Alitak Bay samples and were markedly absent from daytime hauls. Nighttime catches were nearly tenfold greater than comparative daytime catches. The mean length of pinks from nighttime catches was 118.21 mm, and from daytime catches 104.39 mm.

Reasons for the diel catch variation are speculative, but one of a combination of two factors seems most likely: (1) because of their better swimming ability, larger fish can avoid the net; (2) during the daytime larger fish occupy depths beyond the effective fishing depth of the net (the tow net fishes to a depth of 9 ft.).

To minimize the bias of diel variation on our townetting indices, we limit daytime towing to a seasonal period when fish sizes average less than 75 mm. This period extends until late July in Alitak Bay and until early July in Uganik and Uyak Bays. When the mean lengths approach 75 mm, the townetting operation is shifted to nighttime.

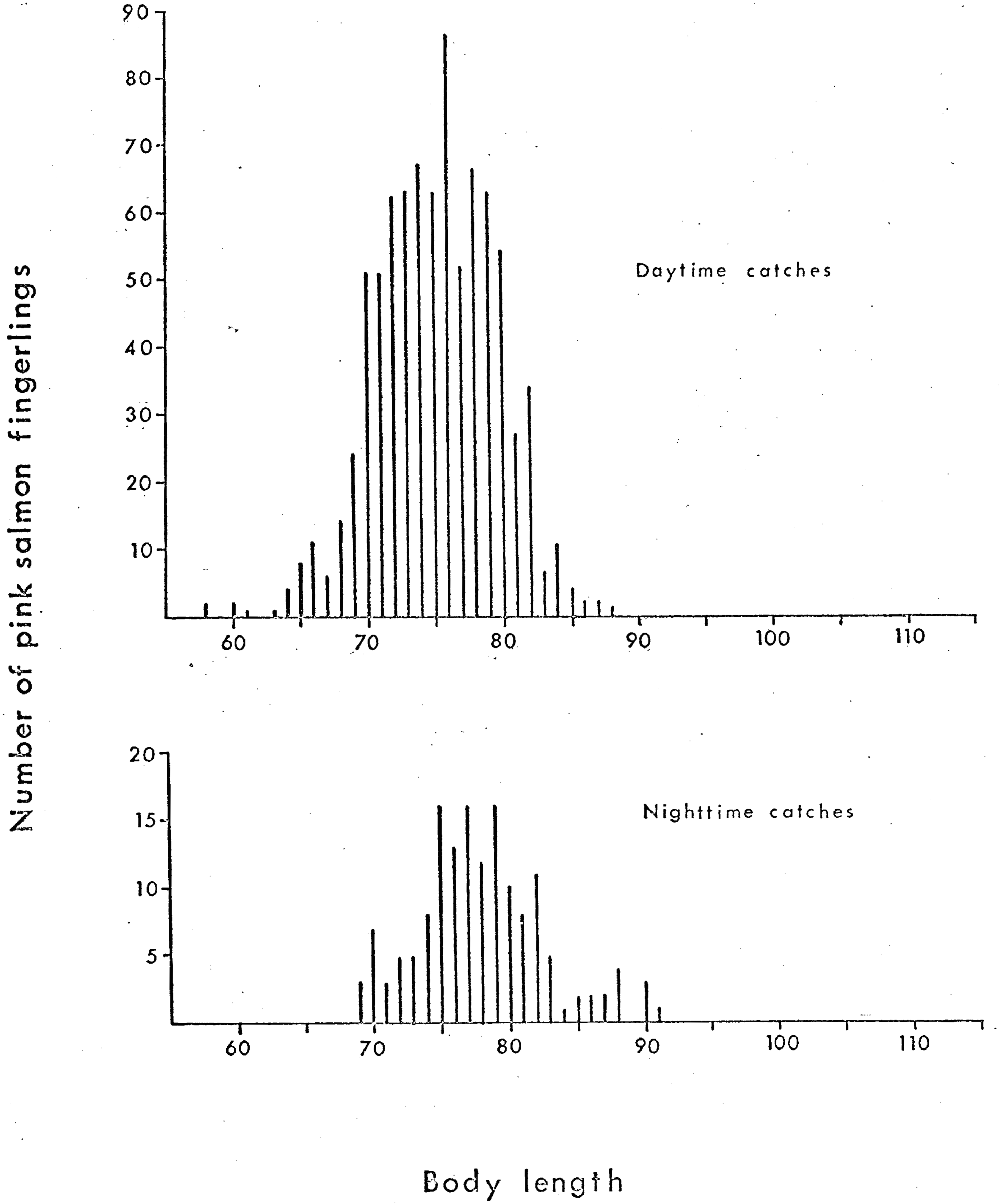


Figure 3. Comparison of length frequencies between daytime and nighttime catches of pink salmon fingerlings from Olga Bay, July 27-28, 1963.

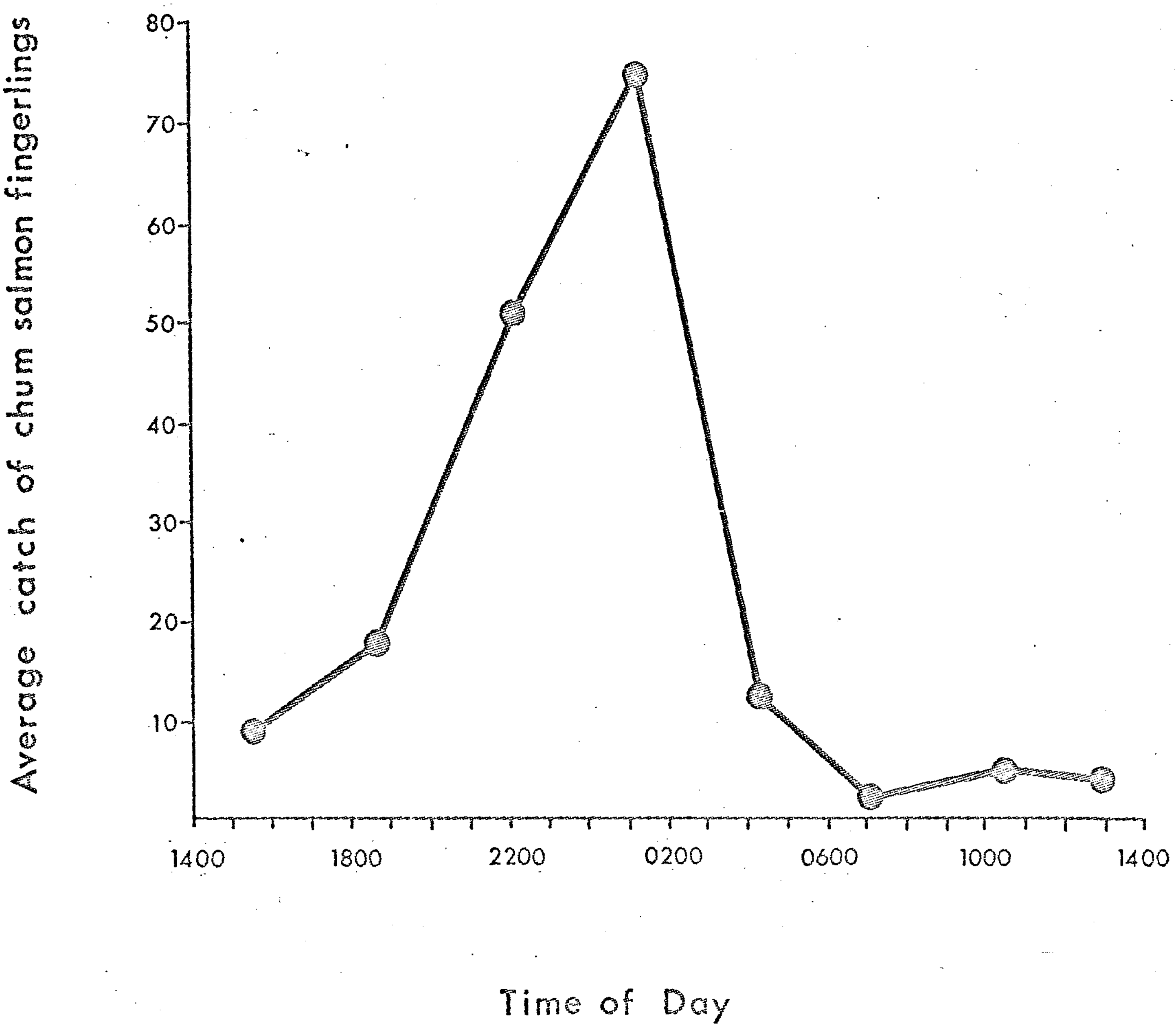


Figure 4. Diel variation in tow-net catches of chum salmon fingerlings from Olga Bay, July 27-28, 1963.

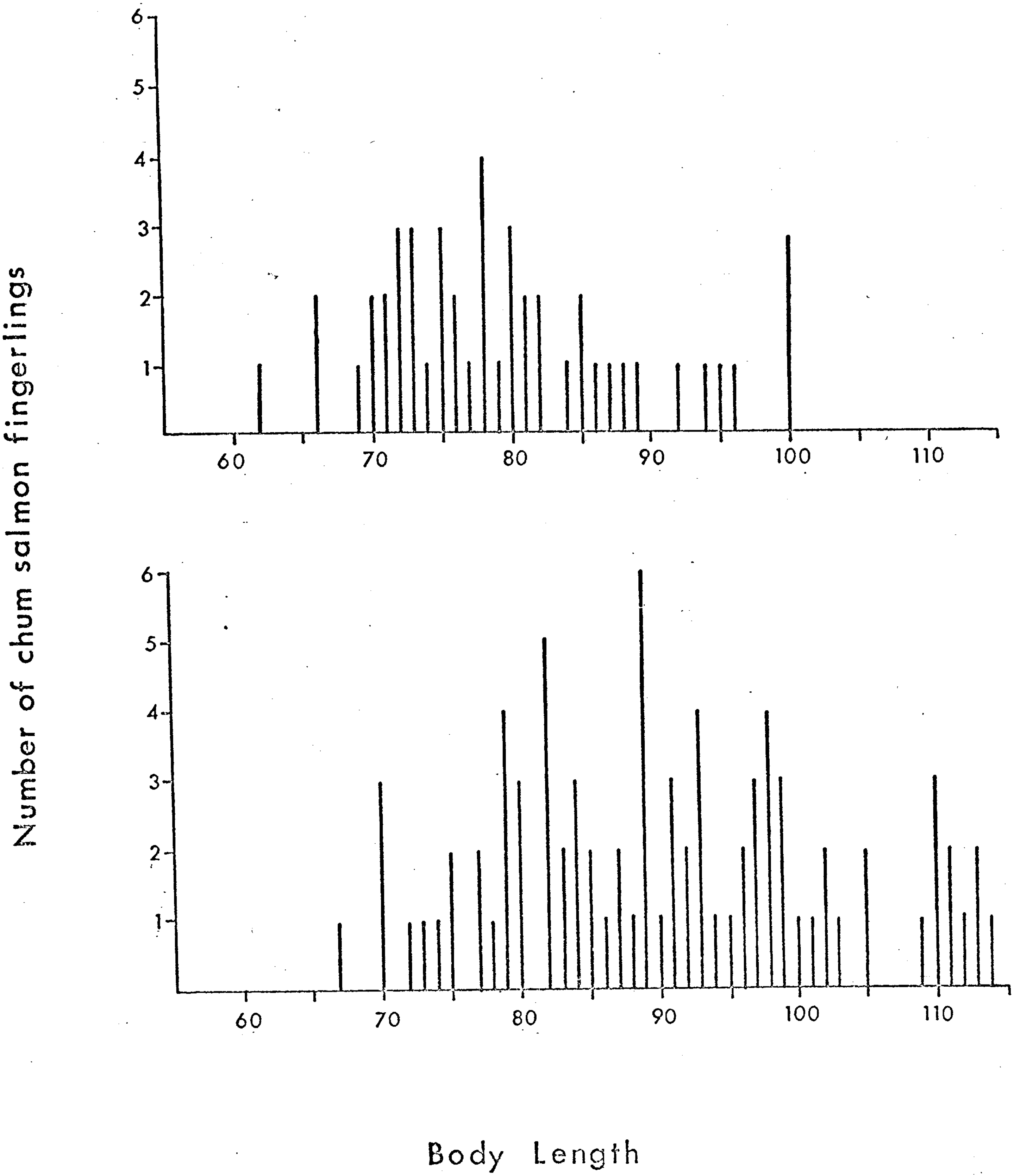


Figure 5. Comparison of length frequencies between daytime and night-time catches of chum salmon fingerlings from Olga Bay, July 27-28, 1963.

Much of the effectiveness of the Kodiak trawl apparently is due to a funneling of the fish caused by the two boats immediately preceding the net. Comparative hauls made with varying towline lengths demonstrated that the largest catches are made with the shortest towline. Young salmon have been observed to shy away from the towing boats to a distance of 10 or 15 ft. Those fish passing between the towing boats thus lie more directly in the path of the tow net. Since the catches decrease as the tow net is fished farther astern, it is evident that the young salmon disperse soon after the boats pass. For surface hauling the net is therefore positioned within 15 ft. astern of the towing vessels.

Gear and Techniques, 1965

Since the sampling gear and techniques are relatively new, they are still evolving. Changes are made each year to improve the efficiency of the sampling and the continuity of the data. In 1965, the sampling entailed a two-step procedure. First, a rapid, preliminary series of trawl hauls was made throughout the study area in order to locate concentrations and voids in fish distribution. Second, areas of concentration were resampled in greater detail to define the exact limits and densities of the concentrations. The precise locations of hauls were recorded either by sextant sightings or by radar plots. As in previous years, the salmon catches were then plotted by location on grid maps and subsequently delineated by isometric lines according to the density of the fish (Figure 6). These isometric graphs enable us to make the weighted estimates of abundance which serve as forecast indices.

This year a refinement of the Kodiak trawl was made to facilitate surveying of the dense fish concentrations which occur in Alitak Bay. The trawl was lengthened by 10 ft. and reshaped to lay near the surface at the cod-end. A 10-ft. fiberglass skiff was attached just forward of the cod-end so that a man riding in the skiff could remove the contents of the net while the haul was in progress. This feature enabled us to continue hauling for several hours without stopping to process the catch, and thereby double the speed of sampling.

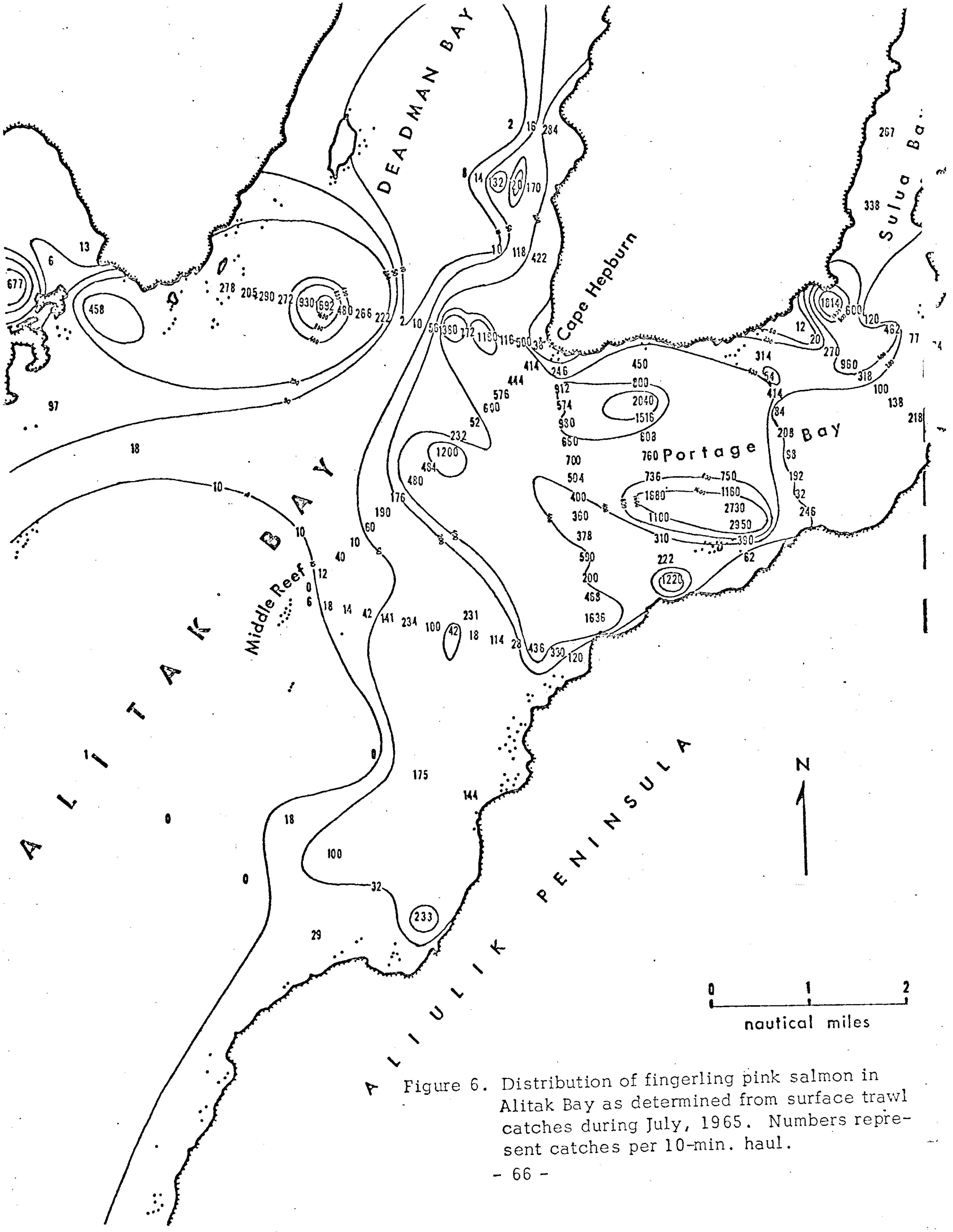


Figure 6. Distribution of fingerling pink salmon in Alitak Bay as determined from surface trawl catches during July, 1965. Numbers represent catches per 10-min. haul.

The Forecast for 1966

We now have sufficient information to permit forecasts of adult salmon runs to Alitak, Uganik and Uyak Bays. In addition, Olga Bay, which is surveyed as part of the Alitak Bay system, is sufficiently isolated to permit a separate forecast of its run. The forecast data for all bays are presented in Table 1.

Where possible, we base forecasts on comparisons between years within the odd-year cycle in order to avoid possible bias from inherent differences in ocean survival rates between odd-year and even-year runs. This method was followed to derive the 1966 forecasts for Alitak, Olga, and Uganik Bays where surveying was begun in 1963, but not for Uyak Bay where surveying was begun in 1964. The Uyak Bay forecast was based on a comparison between odd-year and even-year runs and is therefore considered less reliable.

The forecasts for 1966 are generalized because the validity of the forecast technique is yet unproved; we will have good measure of its reliability only after the juvenile to adult ratio has been determined for at least two cycle years.

In 1966 we look for a fairly good run to Alitak Bay, a poor return to Olga Bay, and good returns to Uganik and Uyak Bays.

Table 1. Relative annual abundance of pink and chum salmon fingerlings based on tow-net catches in Alitak, Olga, Uganik, and Uyak Bays, Kodiak Island, in 1963, 1964, and 1965.

	1963	1964	1965
Alitak Bay			
Pink salmon	63,692	30,876	17,598
Standard tows	296	83	85
Fish/tow	215.2	372.0	207.0
Chum salmon	3,576	127	12
Standard tows	296	83	85
Fish/tow	12.1	1.5	0.1
Olga Bay			
Pink salmon	17,036	538	48
Standard tows	96	18	12
Fish/tow	177.4	29.3	4.0
Chum salmon	1,835	29	1
Standard tows	96	18	12
Fish/tow	19.2	1.1	0.1
Uganik Bay			
Pink salmon	2,595	564	2,346
Standard tows	81	43	76
Fish/tow	30.8	13.1	30.9
Chum salmon	723	198	2,507
Standard tows	81	43	76
Fish/tow	9.0	4.6	33.0
Uyak Bay			
Pink salmon	-	1,229	2,965
Standard tows	-	21	40
Fish/tow	-	58.5	74.1
Chum salmon	-	275	157
Standard tows	-	21	40
Fish/tow	-	13.6	9.9

DISCUSSION

Mr. Roys: How much of a difference was there between estimates of the 1964 and 1965 Alitak runs?

Mr. Tyler: I haven't examined the catch statistics. Estimates of escapements indicated a poor escapement in Dog Salmon River and a fairly good escapement in Humpy Creek, the main contributor to the Alitak Bay area. Last year the pattern of fishing changed drastically because of the strike.

Dr. Bevan: I think we should caution against two things here. One is making comparisons across years of different cycles, because the chance of differences in behavior in the estuary in different years is equally as great as known differences between location of fish on the high seas in different years.

The other point is differences in time between areas of sampling; obviously, with one vessel and one crew, Uganik Bay and Alitak can't be sampled simultaneously. Figures for Alitak and Uganik should not be compared because fish are of a different size at different times of the year. They are, however, fairly consistent in size relation from year to year within an individual bay.

Mr. Tyler: In 1963, we made duplicate surveys in all the sampling areas and had similar results.

Mr. Hoffman: Did you make any comparisons with the fry digging?

Mr. Tyler: Estimates of numbers of pre-emergent fry indicated a low abundance throughout Alitak and Olga Bay. This agrees with our prediction for Olga Bay, but is in contrast with our prediction for Alitak Bay.

Mr. Yunge: Since most observations show the pink salmon juveniles swimming close to shore, is there an indication that this species requires a bay for their natal stream to empty into?

Mr. Tyler: No, there are many pink and chum streams which empty directly into the ocean.

Mr. Noerenberg: What differences did you get between day and night catches?

Mr. Tyler: While fish are 50 to 75 mm long we found practically no difference. When they become larger than 75 mm, night towing is by far the best; from 9 in the evening until 3 in the morning.

Mr. Noerenberg: When did they reach 75 mm?

Mr. Tyler: In Alitak Bay in late July.

USE OF VERTEBRA COUNTS AND SCALE MEASUREMENTS (CHARACTERS) IN PINK SALMON RACIAL STUDIES

Roger E. Pearson, Bureau of Commercial Fisheries, Seattle

INTRODUCTION

Since the last pink salmon workshop, considerable interest has developed concerning the role of racial studies in forecasting. This spring and early summer, biologists from the Fisheries Research Institute and the Nanaimo Laboratory of the Fisheries Research Board of Canada plan to identify specific stocks in samples taken off Alaska and British Columbia, and to use this information in their forecasts. My organization, the Seattle Biological Laboratory of the Bureau of Commercial Fisheries, is not actively engaged in this program. However, the techniques and racial characters used at Nanaimo and the University of Washington will be similar or identical to the techniques and characters we have used in studies for the International North Pacific Fisheries Commission. I would like to take this opportunity to (1) show you the ranges in mean values of two racial characters obtained from our North American samples, and (2) explain the value of these two characters for identifying area of origin of pink salmon caught on the high seas.

TOTAL VERTEBRAE

The first character is the total number of vertebrae. With the possible exception of some scale measurements, this is the best character that we have found for our racial studies. It is not significantly correlated with body length, is not significantly different between sexes, and it has a rather small (0.7 to 0.9) within-sample variance compared to the differences between some stocks (Figure 1).

Figure 1 shows that in 1957 and 1958 the mean number of vertebrae generally became progressively larger going northward in North America. With the exception of Cook Inlet and Kodiak Island, samples from the same

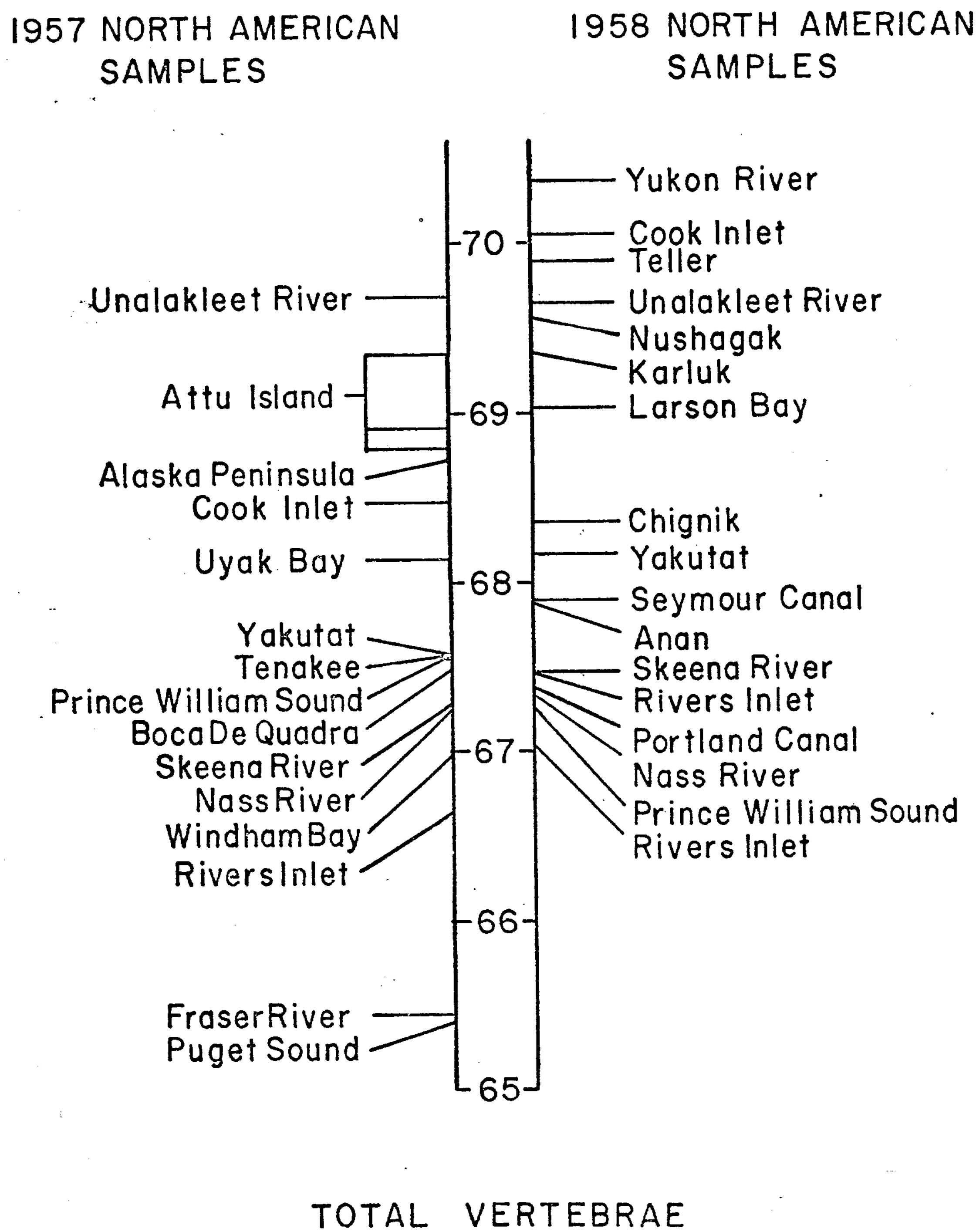


Figure I. --Linear comparison of mean values of total vertebrae for North American samples collected in 1957 and1958.

region tended to have similar mean values between years. Unfortunately, fish from central British Columbia, northern British Columbia, southeastern Alaska, and Prince William Sound had similar numbers of vertebrae.

This character was used in our I.N.P.F.C. studies and will also be used by the biologists in Nanaimo. At the present time, it is the only known character that can classify Fraser River-Puget Sound fish to region of origin.

DISTANCE FROM THE FOCUS TO THE 30TH SCALE CIRCULUS

The second racial character is a measurement taken from the surface of a scale, the distance from the center of the focus to the 30th circulus (scale character 19). This scale character is the best of a rather large number of scale characters that has been studied. Like total vertebrae, it is not significantly correlated with body length, is not significantly different between sexes, and the within-sample variance is small compared to the differences between some stocks.

Our scale sampling was expanded in 1963. Prior to this date, our scale sample sizes were small, North American coverage was limited, and the scales were not always taken from a standard body position on the side of the fish.

Figure 2 shows that in 1965 and 1964 the mean value of character 19 became progressively larger going northward, and within all regions larger mean values occurred in 1965. In both years, samples from northern southeastern Alaska had larger mean values than samples from southern southeastern Alaska, and British Columbia.

Figure 3 shows the mean values of character 19 in 1965 and 1963 North American samples. Note the similarity between the 1963 and 1965 samples from the same regions. It is too early to tell if this pattern will continue in other odd- and even-numbered years, but some of my scale data in the I.N.P.F.C. 1965 Annual Report showed that between 1957 and 1964 samples from Kodiak Island had larger mean values in odd-numbered years.

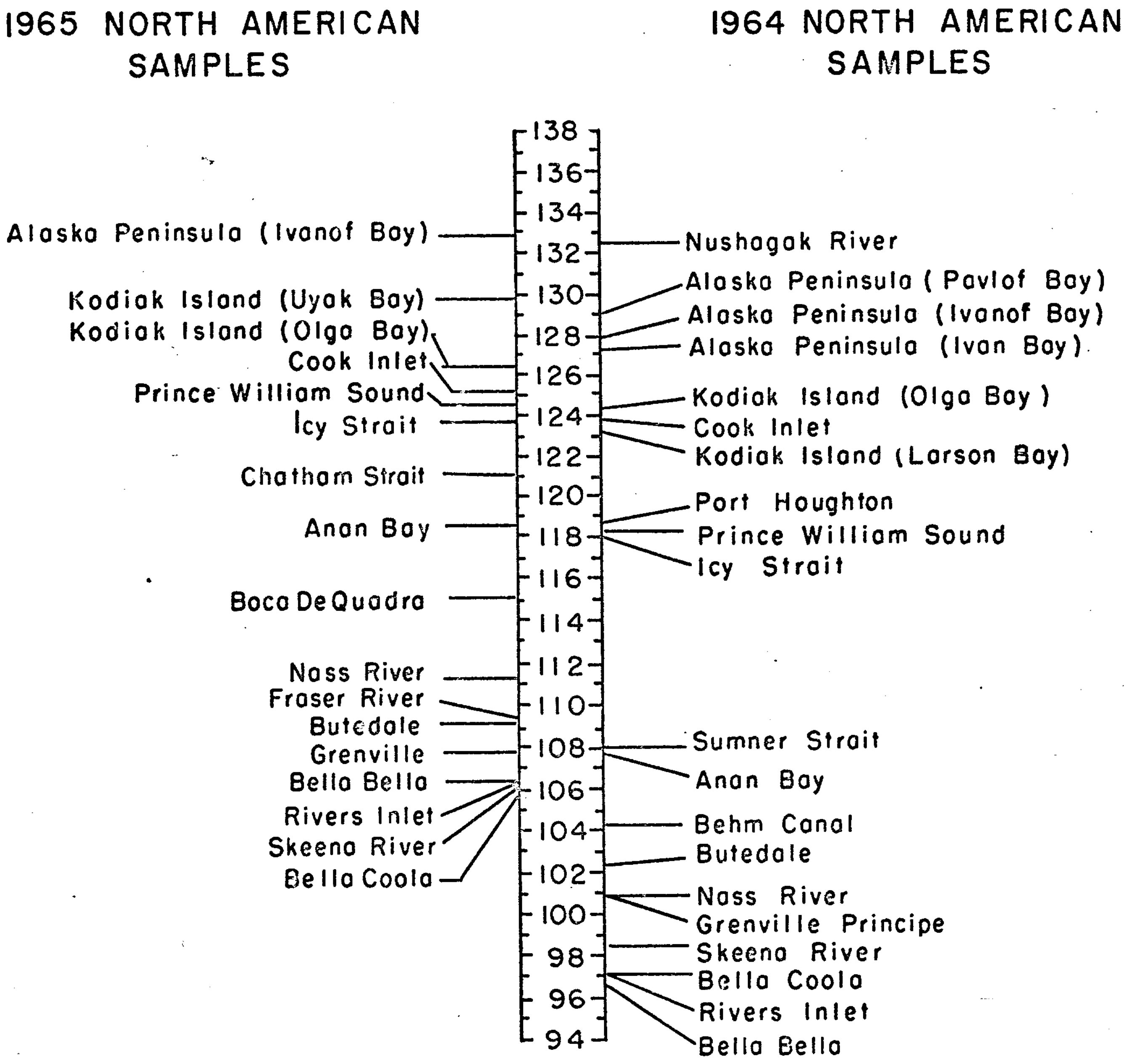


Figure 2.--Linear comparison of mean values of width (1/100 mm) from center of scale focus to 30th circulus for North American samples collected in 1965 and 1964.

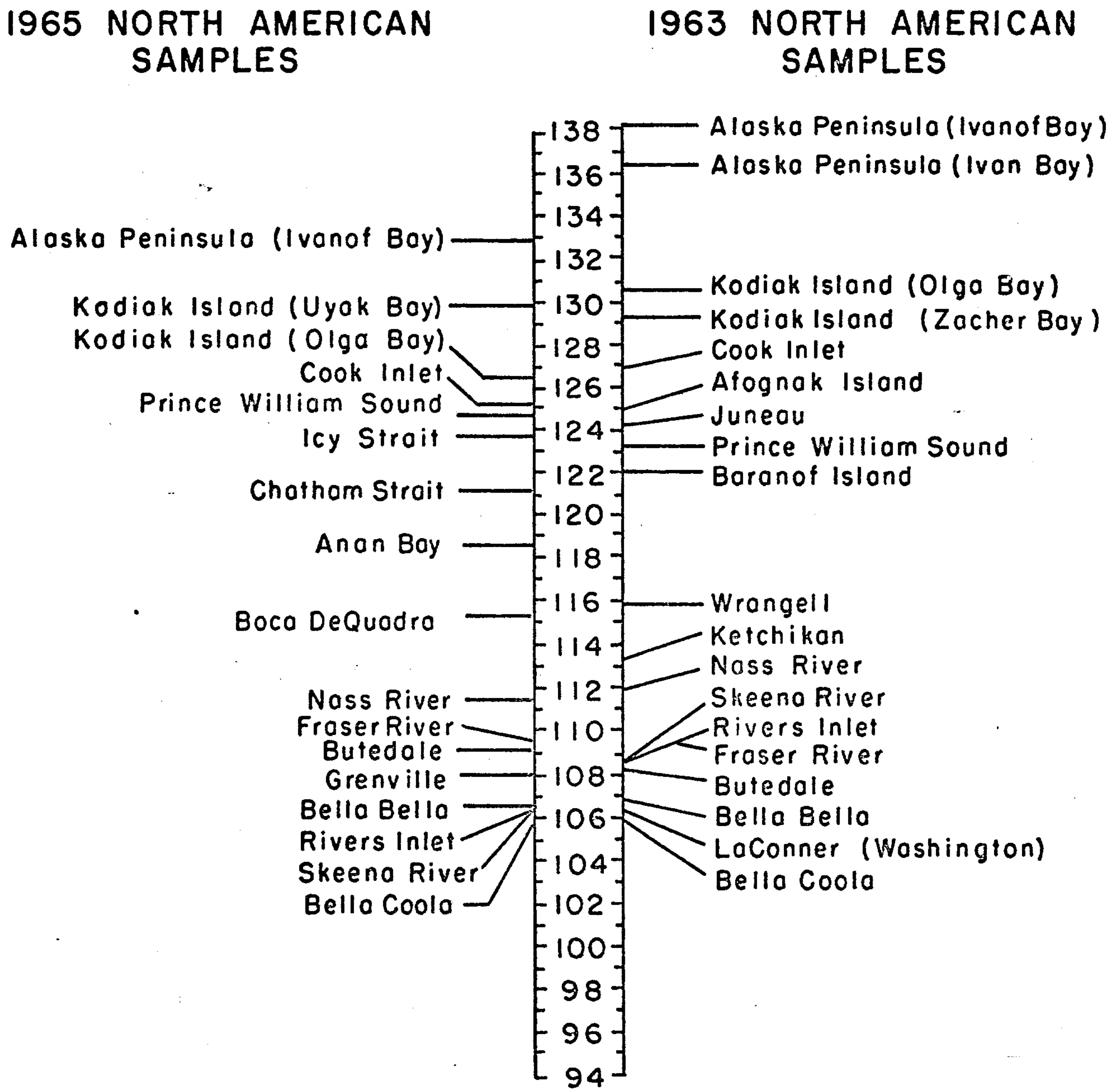


Figure 3.--Linear comparison of mean values of width (1/100 mm) from center of scale focus to 30th circulus for North American samples collected in 1965 and 1963.

In the same 1965 Annual Report, I used character 19 to determine the most likely region of origin of eight high seas samples taken in 1963 (Figure 4). Here, scale character mean values of the eight high seas samples were compared to character mean values from 1963 spawning region samples. The mean values of five high seas samples were similar to mean values found in British Columbia and southeastern Alaska samples. One high seas sample had a mean value similar to those of Baranof Island and Prince William Sound. Another sample was most similar to Washington and British Columbia. The eighth high seas sample had a mean value close to Afognak Island, Cook Inlet, and Kodiak Island.

Of course, a simple comparison like this cannot be used for samples having fish from several different areas of origin. In the case of Figure 4, standard deviations of the high seas samples were only slightly larger than the standard deviations of the inshore samples. The low standard deviations showed that few fish with different scale measurements were present in the high seas samples. This suggested that most of the fish in each sample were from one region; or the high seas samples were composed of fish from more than one spawning area with common character means and variances.

If high seas samples consist of mixed stocks, a multivariate normal technique can be used by which individual fish are classified to one of a number of spawning regions by means of a set of scale characters and vertebra. We have used a discriminant function analysis with six characters to determine the continental origin of pink salmon taken from the North Pacific Ocean, and the Canadians plan to use a similar analysis to determine the region of origin of pink salmon taken in the Gulf of Alaska.

CONCLUSION

In conclusion, I would like to state that racial studies for Gulf of Alaska pink salmon are of a preliminary nature. We know that some differences between vertebra counts and scale measurements exist between stocks and this information is going to be used by FRI and Canadian biologists to identify certain stocks in samples taken off Alaska and British Columbia. Unfortunately, the differences in scale measurements and vertebra counts

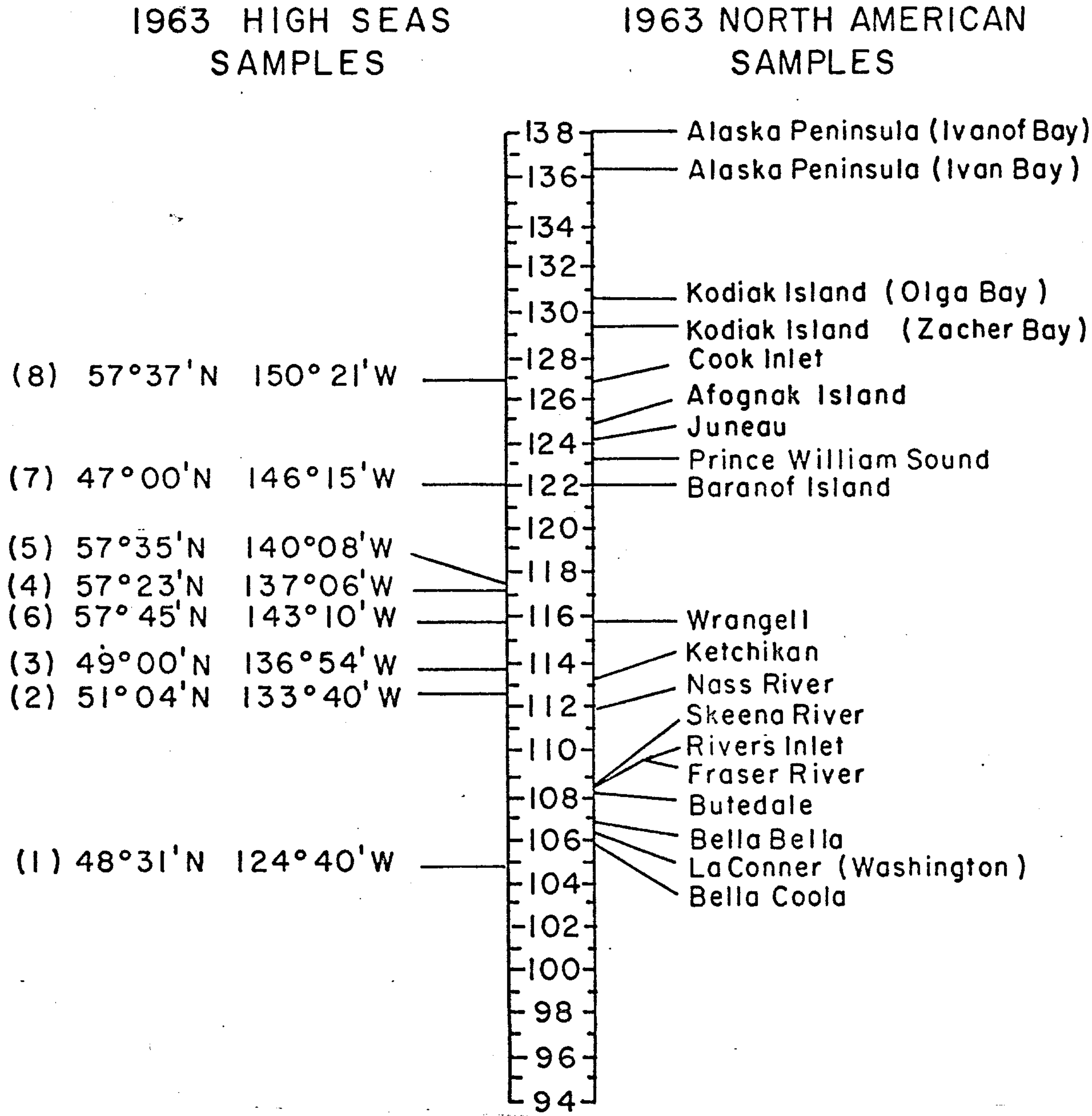


Figure 4.--Linear comparison of mean values of width (1/100 mm) from center of scale focus to 30th circulus for 1963 high seas samples and 1963 North American spawning region samples.

between some stocks are small, and our present samples are from a very small number of the total pink salmon streams in North America. However, racial studies may provide that important piece of information needed in forecasting, "... where is that large school of fish laying off our coast going to spawn?"

DISCUSSION

Mr. Kilambi: Have you conducted studies on parasites?

Mr. Pearson: We have in the past conducted studies on parasites on salmon all over Alaska.

Anon: What will be the outcome of the discriminant function analysis?

Mr. Pearson: It's too early to say what the Canadian discriminant function analysis will show regarding pink salmon. They are running the analysis this week and will construct a model.

Mr. Noerenberg: All the stocks are mixed. Do you think that next summer you can tell from the samples if the fish are from Western Alaska, Central Alaska, Northern British Columbia and Southeast Alaska?

Mr. Pearson: Since the stocks are mixed, it would be difficult, running them through one at a time in a discriminant function analysis. I do think that within a reasonable limit, say 75 percent, we can say fish are from B.C., S.E. Alaska, Kodiak Island, Cook Inlet, etc.

Dr. McNeil: Even if we can base a prediction on high seas indexing, it may be necessary to go to stream indexing to define the origin of specific stocks?

Mr. Pearson: Yes, high seas distribution is only another tool to use. For example, when fish are caught in Icy Strait, we wonder if these fish are really from that particular area.

Dr. Parker: You may also be sampling from stocks passing through the area. For instance, there are no spawning streams in Rivers Inlet, yet I see it listed. The catch was made in Rivers Inlet, but the fish came from Bella Coola. The same applies to Bella Bella.

Mr. Pearson: This is correct. We instruct the people to get local fish, but this is hard to guarantee.

Dr. Parker: Even in southeast Alaska, where you may think your sampling is good, Leon Verhoeven showed that fish move randomly, around this island we are now on.

Mr. Pearson: I agree, but our scale samples do show that the northern samples are quite different from the southern samples. There may be error, but most of the fish have a different scale pattern and the within sample standard deviation doesn't appear to indicate mixing.

PROSPECTS FOR FORECASTING PINK SALMON RUNS A YEAR IN ADVANCE ON THE BASIS OF FINGERLING CATCHES AT SEA

Allan C. Hartt, Fisheries Research Institute, Seattle

At the time of the 1964 pink salmon workshop we were in the process of planning our first joint Gulf of Alaska longline indexing program with Canada, and were also planning our first attempt to study fingerling salmon as they enter the coastal waters of the Gulf of Alaska. On the basis of data then available, we concluded that because of the tremendous mixture of stocks within the Gulf and the varying timing of the runs, forecasting from longline indexing might have to be limited to the Gulf as a whole, although it might be done also for a few individual stocks that occupy distinct areas at sea such as central B. C. fish. No prospects could be stated for forecasting yield a year in advance on the basis of fingerling abundance at sea.

I can now treat the subject of fingerling abundance with the results of the 1964 and 1965 operations behind us. Progress in the indexing of abundance of mature fish by longlining will presumably be reported by Canadian scientists.

I would like to emphasize, however, that these fingerling studies were not designed for forecasting; they were undertaken to gather information on the early ocean life history of salmon and to round out our understanding of the total oceanic migratory period.

From August 4 through September 25 of 1964 using a fine-meshed puse seine, we searched for fingerling salmon of all species along the eastern shore of the Gulf of Alaska from Cape Flattery to Lituya Bay. We fished at various distances from shore with the opening of the seine set in different directions. It became evident that vast numbers of fingerling salmon of all species were migrating northward along the coast in a belt about 15 miles wide. An extrapolation of catch data by area and time indicated that over a million per day of mixed species migrated past any given point between the Queen Charlotte Islands and Lituya Bay during the observation period. Individual seine catches ran as high as 1,200 per set. Pink salmon comprised over half the catch in most areas. The average catch of pinks in all areas was 200 per set. On the average, fingerlings were of larger size in the northern areas, which would be expected if these were the fish that had been at sea the longest. Intermixed with these fish, however, were smaller fish, presumably those that had just entered the sea from adjacent coastal channels.

In 1965, sampling commenced on July 21 and terminated on September 24. Sampling was extended around the northern periphery of the Gulf to Kodiak Island. In the areas that could be compared, the migration pattern and the width of the belt of fish were the same as in 1964. The limited operations to the north and west showed that the belt of fish continued on around the coast, and that substantial numbers were migrating southwestward through Shelikof Strait as well as on the Gulf side of Kodiak Island. The belt of fish was wider in the northern Gulf, probably because the continental shelf is wider there.

We may now safely conclude that upon entering the Gulf, juvenile salmon do not scatter randomly, but proceed rapidly northward in a concentrated belt close to shore. This finding is an important contribution to our knowledge of oceanic migrations of salmon and will probably have parallels among stocks originating in other coastal areas. Moreover, it suggests the possibility of indexing abundance at this early stage at sea and may ultimately lead to forecasting pink salmon runs a year in advance, and perhaps to forecasting runs of other species even further in advance.

Over-all average catches of fingerling pinks were 200 in 1964 and 70 in 1965, or a ratio of about 3:1. As stated earlier, although these studies were not intended for forecasting purposes, it would seem that in view of the uniform behavior of the fish each year, the abundance must have been less in 1965 than in 1964. For comparison, red, chum, and coho salmon yielded moderately smaller catches in 1965, whereas chinooks, which were practically absent in 1964, were taken in small numbers in all areas fished in 1965.

As the present seining studies are continued and the associated biological data are further analyzed, the possibilities for indexing and forecasting will become clearer. Studies now in progress of length, scale features, vertebral counts, and parasites indicate some clear-cut patterns of oceanic distribution within the areas and time period sampled. The identifying features of certain coastal stocks as worked out by the Bureau of Commercial Fisheries and Canadian scientists may be useful in keying some of the fingerling to their source. Such identification should enable us to ascertain the rate of travel of juvenile salmon during the initial oceanic migrations. It is conceivable that careful observation of internal and external physical condition and growth may reveal indices to mortality during this early period of oceanic life.

The important tagging phase of the fingerling salmon research has not been very successful to date. Pink salmon tagging in particular was a failure in 1964. We used plastic dart tags 1/6 in. in diameter and 2-1/2 in. long, inserted in the dorsal musculature. There were no returns from more than 1,000 pinks tagged. In contrast, the 368 cohos tagged yielded 6 returns (1.6%). The cohos, being larger, probably retained the tags better, having a much larger mass of muscle to hold the dart. In 1965 we tried two different tags--a modified dart tag with a knot in the tube in place of the barb, and the Carlin dangler. Results will be available in 1966. The problems of handling and scaling are being further studied, since if meaningful numbers of returns are to be received from salmon tagged as fingerlings, injury must be minimized and larger numbers must be tagged rapidly and uniformly.

We might now pose the question of the feasibility of forecasting the pink salmon runs on the basis of the relative abundance of juveniles during the early sea life. In comparison with sampling matures in the spring and summer, fingerling sampling would certainly provide better lead-time and might even enable forecasts for some individual production areas.

Sampling at the earlier life stages in bays and inner channels would accomplish the same purpose and would probably be more specific as to area, but would provide unreliable indices in the event of high early ocean mortality. In this regard, the reduced abundance in 1965 was evident not only in the Fisheries Research Institute offshore seine sampling, but also in the Bureau of Commercial Fisheries observations and sampling in the coastal bays and channels of southeastern Alaska.

If seine indexing is attempted for the entire Gulf, it would require the observation of at least three boats from July 1 through October 1: one off British Columbia, one off southeastern Alaska, and at least one in the Prince William Sound, Cook Inlet, Kodiak area. We would have to obtain an adequate number of sets, standardize areas of sampling, and identify the source of the specimens sampled. However, it seems safe to say that such an effort would enable us to predict the general order of magnitude of the run to major production areas.

DISCUSSION

Mr. Hartt: If we are going to attempt forecasts based on catch of juvenile pinks in the Gulf, we will need three boats: one for the Washington, British Columbia coast, one for southeast Alaska and one for Prince William Sound, Cook Inlet and Kodiak. Such an operation would be costly.

Mr. Martin: You suggested that the magnitude of the catch increased north of Dixon Entrance.

Mr. Hartt: That is correct. Some pinks originate south of the Queen Charlotte Islands with another increment coming through Dixon Entrance. In 1965, the catch off the Queen Charlottes was practically zero while in 1964 we got over 300 pinks in one set.

Mr. Simon: How many fish did you tag last year?

Mr. Hartt: I can't recall offhand, but I made a table which you will soon receive. The final return was about three percent.

FORECASTING CHUM SALMON RETURNS BASED UPON PINK SALMON ABUNDANCE OF SAME BROOD YEAR

Chester R. Mattson, Bureau of Commercial Fisheries, Auke Bay

The possibility of predicting relative abundance of four-year-old chum salmon based upon adult pink salmon returns of the same brood year was first examined in 1959, when a close correlation was noted between pink and chum salmon returns to two salmon streams in southeastern Alaska. The basic theory of predicting chum salmon abundance, based on pink salmon returns, must assume that for a time period extending well into the sea life of these species environmental conditions affecting ultimate pink salmon survival have a similar effect upon chum salmon. Certain basic assumptions that must be made include the following:

1. Stream survival rates during spawning, incubation, and outmigration are very similar because the same environmental factors control survival of each species.

2. Transitional, estuarine, and early sea life survival rates are almost identical as seaward migrations occur concurrently with identical environmental factors influencing survival.

3. Open ocean survival may be quite similar as long as the two species intermingle, which may occur until pink salmon begin their spawning migration.

4. Open ocean survival rates generally are presumed to fluctuate less drastically than those within fresh water, basically because environmental factors are more stable and the salmon are much larger and less susceptible to losses.

5. For the purpose of estimating relative abundance of four-year-old chum salmon, the influence of three and five-year-old adults has been minimized. Exceptionally strong or weak year classes can affect the reliability of this prediction method through returns of three and five-year-olds.

Predictions for returns of four-year-old chum salmon must allow consideration for unpredictable fluctuations in survival between the time adult pink salmon leave the ocean and the return of adult chum salmon. This approach toward predicting adult four-year-old chum salmon returns must be considered as a rough approximation, but under certain conditions results have been encouraging.

Data Analysis for Individual Streams

Considering the foregoing assumptions, adult pink and chum salmon returns for brood years 1947-1954 to Herman Creek, in north Behm Canal, and Old Tom Creek, in Skowl Arm, were analyzed (Figure 1). Amazingly high correlation coefficients of $\underline{r}$ equals 0.951 and 0.846 respectively were obtained (Figure 2).

Current information on ocean survival rates of salmon indicate that these are not always constant. Oceanic environmental conditions may change from year to year and may appreciably influence chum salmon survival after pink salmon have returned to spawn. Hence adult chum salmon returns may not be closely correlated with pink salmon abundance at all times.

An example of such a variation is presented in the 1949 brood year chum salmon returns in 1953 to Old Tom Creek. A pink salmon 1949 parent run of 23,000 produced a 1951 escapement of 51,700. The 1951 brood year pink salmon fry production was good as indicated by migrant fry abundance. Yet the resultant 1953 adult return was only 4,000, almost a total failure. Ocean survival of the 1951 brood year pink salmon was considered extremely low, based upon commercial catches and escapement counts, as southeastern Alaska runs were near failures in most areas. Hence environmental factors causing such drastic effects upon ocean survival of pink salmon in 1952 and 1953 also appeared to have affected four-year-old chum salmon returns to Old Tom Creek.

Analysis of Commercial Catches

Analysis was extended to determine if significant correlations in commercial catches within specific statistical areas of southeastern Alaska existed. In applying this concept to commercial fishing areas, special considerations must be given to specific and influencing factors, which decrease reliability as follows:

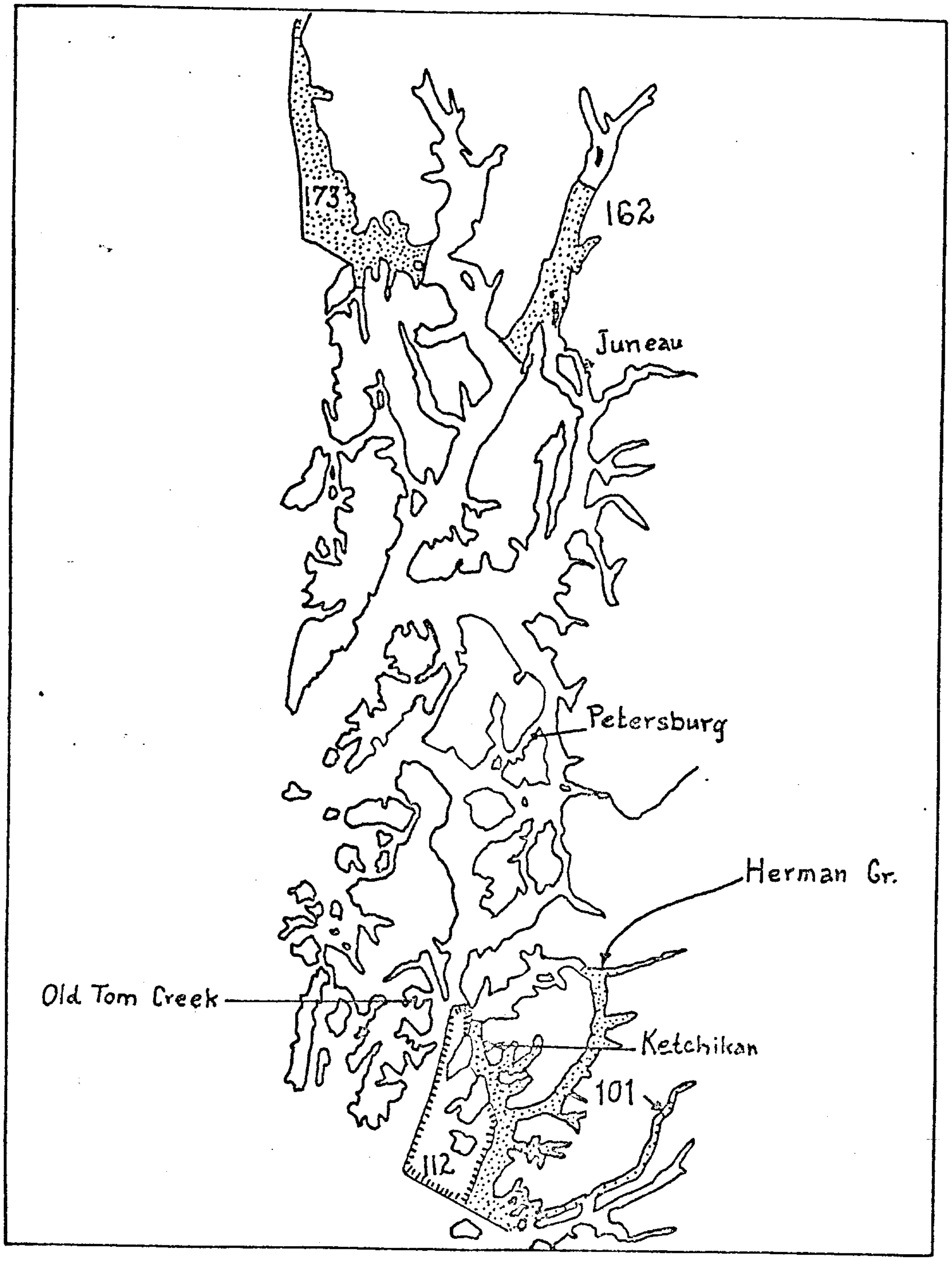


Figure 1. Locations of streams and statistical areas in southeastern Alaska that are pertinent to prediction discussion.

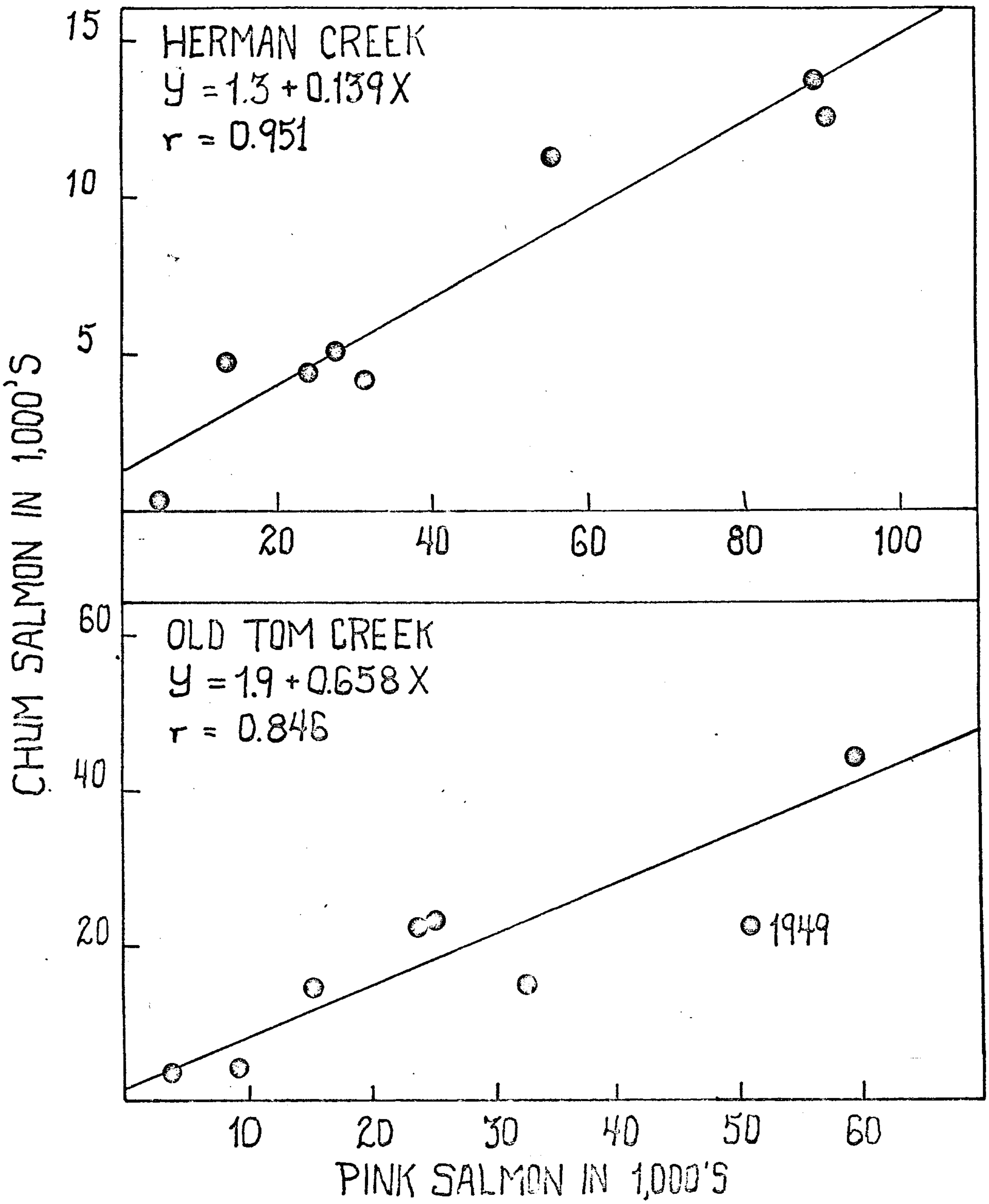


Figure 2. Pink-chum salmon abundance relationships between returns to two weir streams in southeastern Alaska. Data presents dispersions, linear regressions, and correlation coefficients.

1. As the number of streams increase for a unit area, there is a corresponding increase in the variability of environmental conditions encountered. Hence prediction accuracy is unfavorably affected.

2. Areas in which commercial catches consist of high percentages of salmon migrating to distant streams will tend to have less significant correlation coefficients than where salmon spawning within the area.

3. Commercial catches of each species must be substantial to provide meaningful data.

In 1960, when the Alaska Department of Fish and Game assumed management of Alaska's fisheries from the federal government, another major factor, a much greater flexibility in regulating catches, was introduced. This, in turn, affected commercial catches and generally lessened the degree of significance for this prediction concept.

Considerable liberty was taken in interpreting commercial catch data. In the following figures (Figures 3, 4) solid circles represent catch data during federal control (1951-1957) and open circles catch data influenced by state control. Regression lines and correlation coefficients are computed using catch data during federal control; note that later data tend to scatter the points.

The pink-chum salmon abundance relationship in commercial catch data for statistical area 101 in the Ketchikan district during the period 1951-1957 is unsatisfactory for prediction purposes (Figure 2). Inclusion of 3 years of additional data, 1958-1960, from years influenced by state management of fisheries merely raised the correlation coefficient _r_ from 0.654 to 0.674.

Area 101 is not logically suited for application of this prediction concept because (1) it covers too great an area in which freshwater environmental conditions can vary widely, and (2) many salmon races destined for spawning areas beyond are also included in the commercial catch in unknown quantities.

The same relationship for statistical area 112 in Clarence Strait during the 1951-1957 period produced a low correlation coefficient _r_ of only 0.365. However, elimination of the 1949 brood year data, the year

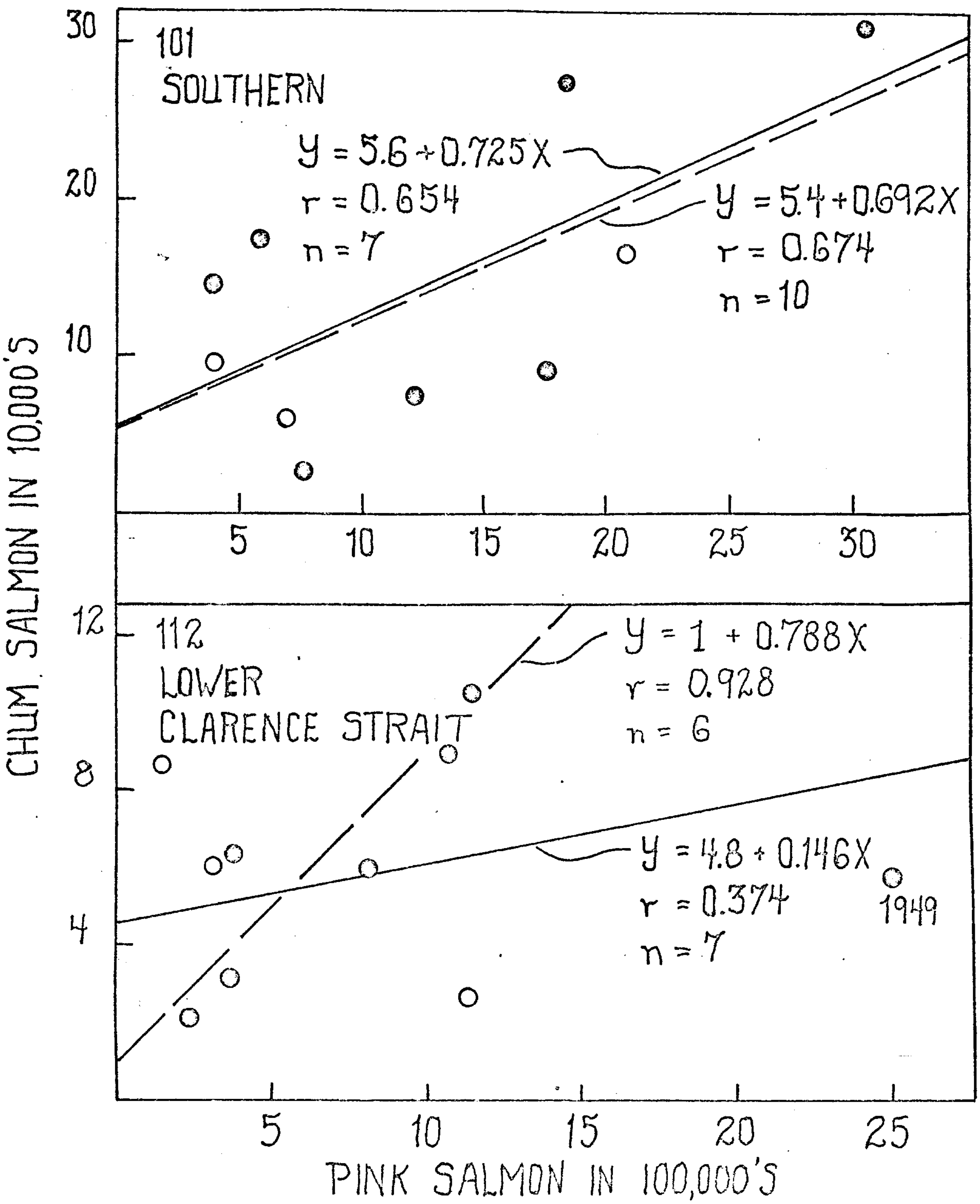


Figure 3. Pink-chum salmon abundance relationships for commercial catches of 1951-1960 for statistical areas 101 and 112. Dispersions, linear regressions, and correlation coefficients are shown. Open circles denote points influenced by state fishery management.

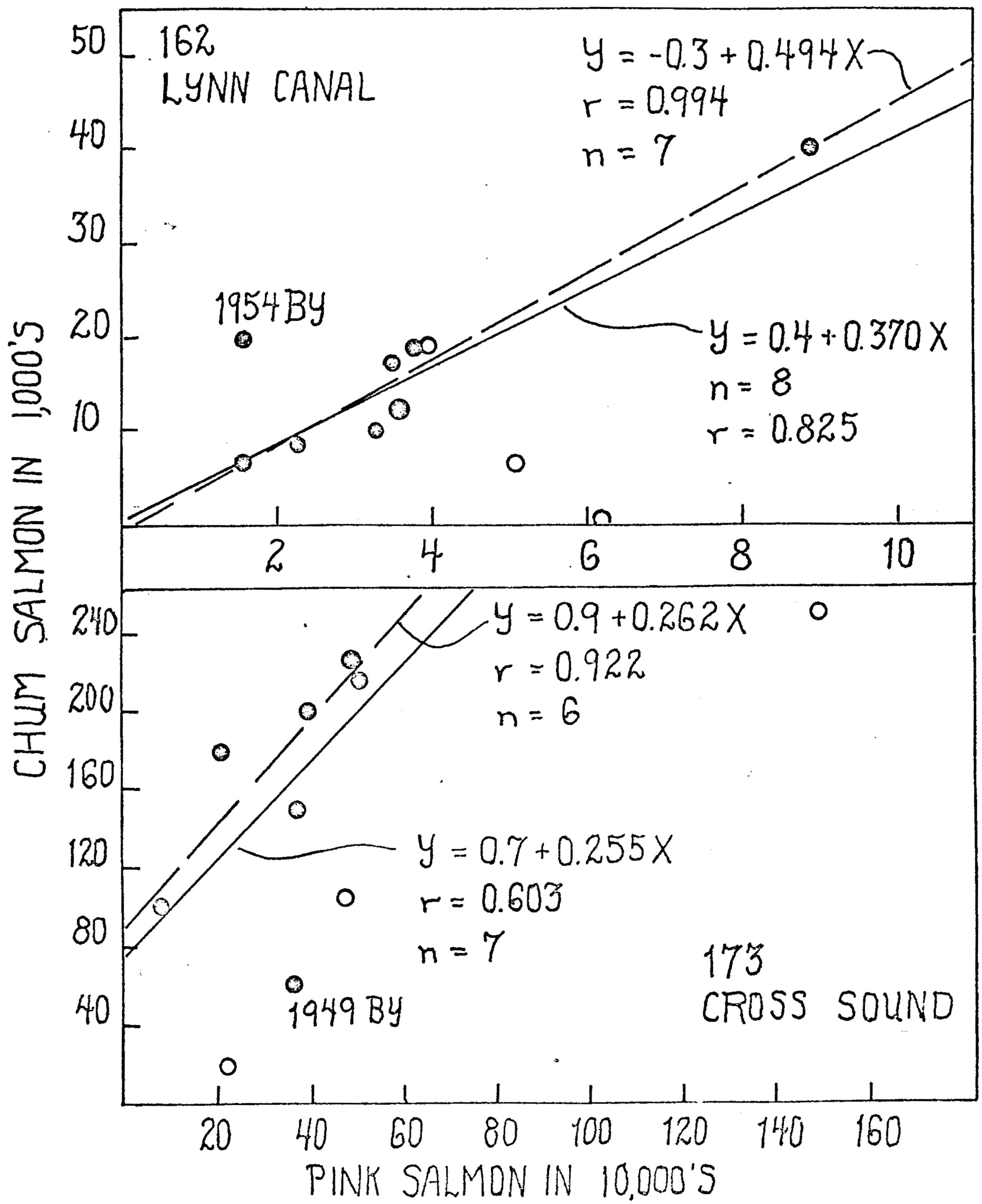


Figure 4. Pink-chum salmon abundance relationships for commercial catches of 1951-1960 in statistical areas 162 and 173. Dispersions, linear regressions, and correlation coefficients are shown. Open circles indicate data influenced by state management.

class in which chum salmon ocean survival during the 3rd and 4th years was unusually low, resulted in a highly significant correlation coefficient r of 0.977. Inclusion of 3 years data influenced by state fisheries control upset the relationship and lowered the correlation coefficient r to 0.128. In fact these three points form a rather good inverse correlation between pink and chum salmon catches.

Data analysis for statistical area 162, which includes all of Lynn Canal except that portion north of Sullivan Island, produced a highly significant correlation coefficient r of 0.825 for the pink–chum abundance relationship for the 1951-1957 period. Returns from the 1954 brood year resulted in a noticeable deviation in which pink salmon returns were well below normal. No cause for this deviation has been ascertained. Elimination of this year class raised the correlation coefficient r to 0.994. Inclusion of three later years of data influenced by state fisheries management reduced the correlation coefficient r to 0.185. These three points form an inverse correlation quite opposite the normal of previous years' data.

The 1951-1957 catch data from statistical area 173, Cross Sound, provided a correlation coefficient r of 0.603. The area catch is composed mainly of migrant salmon bound for numerous and distant streams. Hence the degree of reliability for prediction purposes of this data would be considered somewhat less favorable than for areas closer to or forming the parent streams.

However, elimination of the 1949 brood year greatly improved the correlation coefficient, which increased to a highly significant r of 0.922. Addition of commercial catches influenced by state regulations depressed the correlation coefficient to an insignificant r of 0.446.

In conclusion, the application of this prediction concept is most effective when used with races of pink and chum salmon originating from a single river system. Expanding coverage to include more areas of salmon production tends to decrease reliability of the system because of the greater variability of environmental factors influencing survival. Coverage of areas where the commercial catches are composed mainly of migrant stocks enroute to distant spawning areas generally results in reduced reliability of predictions. This prediction concept does offer an interesting approach to forecasting chum salmon abundance, that, under certain conditions, can still be applied to fishery management.

DISCUSSION

Mr. Yunge: About nine years ago in Puget Sound we found an excellent correlation between pink salmon abundance and abundance of chums two years later. This worked nicely until the chum disappeared.

Mr. Roys: This year I assumed that numbers of 3, 4, and 5 year chums returning to Prince William Sound were going to be similar to other years. By extrapolation we predicted 700,000 chums and got 400,000. Apparently we had very few three-year olds returning where normally there would have been more.

Mr. Mattson: There are streams with unique age compositions. One year the East River in Yakutat had about 95 percent four-year olds and other years 85 percent three-year olds with few four or five-year fish.

FORECASTING PINK SALMON RUNS

Earle D. Jewell, Washington Department of Fisheries, Olympia

The Washington Department of Fisheries is conducting or has conducted the following studies relating to pink salmon predictions.

1. Spawning ground surveys and estimates of total escapements.

2. Gravel sampling to determine egg and fry survival.

3. Downstream migrant studies.

4. Juvenile pink and chum salmon marine surveys.

5. Prediction based on fork lengths of pink salmon taken by the July sport fishery in the Strait of Juan de Fuca.

As yet none of these studies have progressed for enough years to be useful by themselves as predictors of ensuing runs. Used as a group, however, the indicies derived from these studies are useful in determining whether the run is apt to be poor or good.

In 1965 a correlation was developed, relating the total returning pink salmon run to the fork lengths of pink salmon taken in the western strait of the Juan de Fuca sport fishery. This correlation was developed by Frank Haw of the Washington State Department of Fisheries prior to the 1965 pink salmon run and proved to be quite accurate in respect to the 1965 run..

Chum and Pink Salmon Fry Observations in Puget Sound 1964 and 1965

Seven general areas of Puget Sound are defined as related to juvenile chum and pink surveys:

1. Southern Puget Sound - south of northern tip of Vashon Island.

2. Central Puget Sound - northern tip of Vashon Island to Edmonds.

3. Port Susan - Port Gardner, including Holmes Harbor and Saratoga Pass south to Possession Point.

4. Skagit Bay - including Whidbey Island north of Holmes Harbor and all Fidelgo Island.

5. Northern Puget Sound, including Samish and Nooksack areas, and the San Juan Islands.

6. Hood Canal - south of Foulweather Bluff.

7. Admiralty Inlet.

Some qualifying comments should accompany presentation of survey observations for 1964 and 1965. Comparative value of the data is limited in certain areas, mainly due to the nature of the 1964 survey being basically exploratory. Many observations were made of fry without determining species composition. Chum data from Areas 1, 3, and 6 (see above) are presented in accompanying tables. Data from other areas are in the process of being revised and were not available at this time (1 year behind schedule).

It is apparent that juvenile chum populations in 1965 were well below those of 1964, particularly in South Puget Sound and Port Susan - Port Gardner areas. Both early and late runs utilize Hood Canal streams, and the fry surveys suggested poor abundance of early-run progeny and fair to good abundance of late fish.

WESTERN JUAN DE FUCA STRAIT ANGLING DATA [1/] AS AN INDICATOR OF LOCAL PINK SALMON STOCK SIZE

Interspecific competition in fishes increases with similarity in ecological niches and with population size, and the resulting decimated food supplies can effect growth retardation. It follows that, among individuals, the ultimate in niche similarity will occur intraspecifically, increasing with spacial, temporal, and genetic proximity. Nikolsky (1963) gives

1/ From catches landed at Neah Bay and Sekiu, Washington.

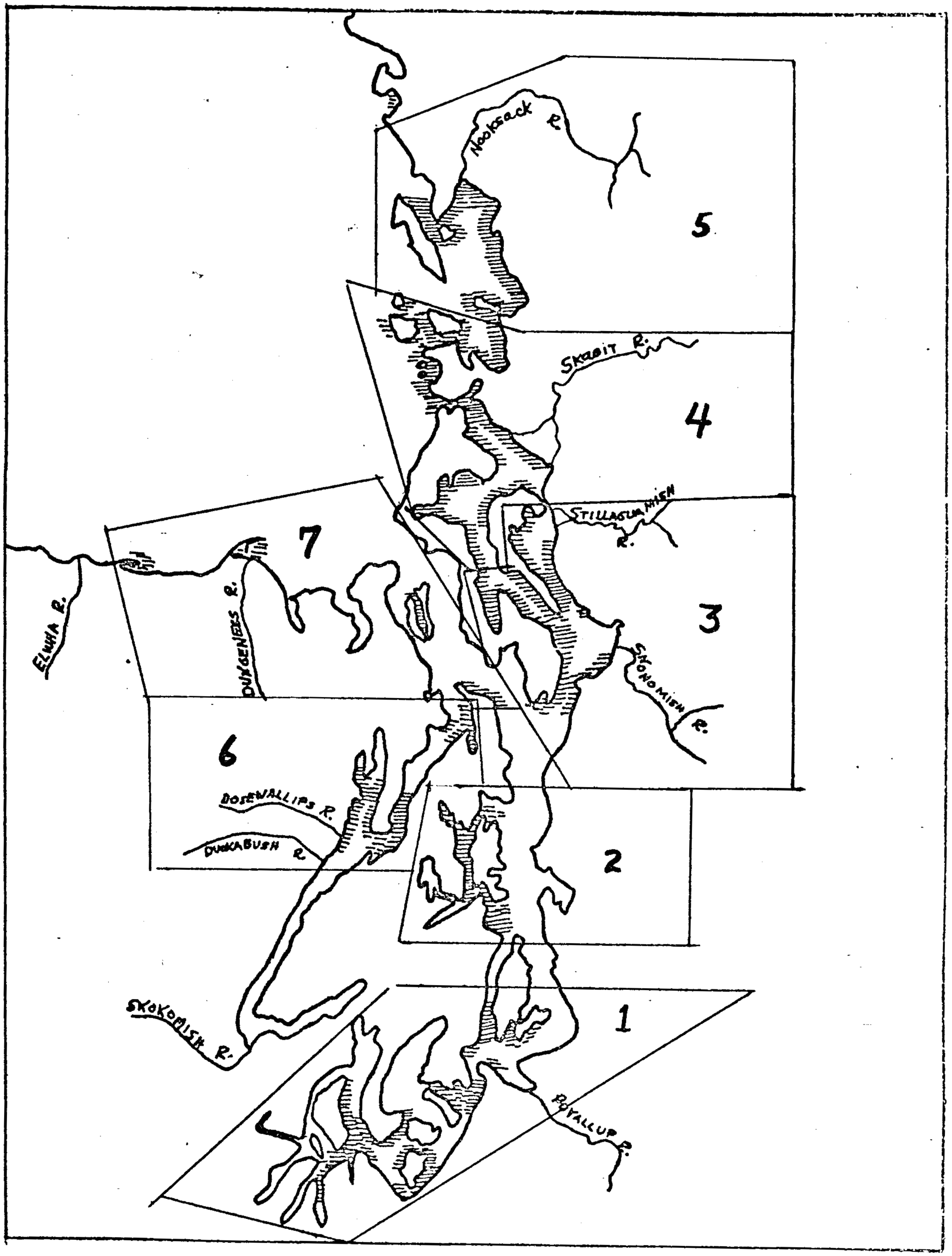


Figure 1. Location map of marine pink and chum sampling areas (shaded) in Puget Sound.

Table 1. Puget Sound chum fry observations - 1964 and 1965 chum fry per nautical mile.

Area	1964	Date	1965	Date
	Southern Puget Sound (Area 1)			
Boston Harbor	7,120	5-8	1,000	4-28
Big Fishtrap Bay	20,940	5-8	800 4	4-28 5-13
Henderson Inlet	1,778	5-8	0 0	4-28 5-12
Johnson Point	1,200 6,400 9,350	5-8 5-19 5-25	0 378	4-29 5-21
Nisqually	13,365	5-8	2,470	5-12
Longbranch	1,929 1,148	5-19 5-25	71	5-20
Anderson Island	40,000 980	5-19 5-25	3,157 1,309	5-21 6-15
Steilacoom	2,410	5-8	70	6-3
Hale Pass	5,152	6-1	67 2,288	5-18 6-3
Day Island and Victory	1,760,000	6-1	3,438 823	5-18 6-3
Gig Harbor	6,435	6-1	10,279 8,750 0	5-18 5-26 6-24
Vashon - Maury	735	6-3	149	5-26
West Pass	4,442	6-3	437 270	5-26 6-24
Combined (Does not include Day Island observation)	11,992		1,627	

(continued)

(Table 1 continued)

Area	1964	Date	1965	Date
	Hood Canal (Area 6)			
Black Point - Pleasant Harbor	22,068 28,400	4-23 5-1	1,009	4-22
Toandos Peninsula	6,200 10,573	5-1 5-14	732 6,209	5-7 5-28
Fisherman's Harbor	2,852 6,200	4-24 5-1	6,193 3,200	5-7 5-28
Seabeck - Bangor	33,500 8,000	5-14 5-28	738 4,440	5-7 5-28
Floating Bridge	1,996	6-5	1,050	4-22
Combined	8,322		3,603	

(Table 1 continued)

Area	1964	Date	1965	Date
Port Susan - Port Gardner (Area 3)				
Possession Point	0	5-5	330 280 160	4-26 5-8 5-26
Columbia Beach	0	5-11	2,718 4,880 660 190	4-26 5-8 5-26 6-10
Hat Island	26,880 763 50,516	4-21 4-27 5-5	2,273 1,272 1,188 300	4-26 5-8 5-24 6-8
Port Susan (Camano side)	531 0	5-5 5-19	1,222 708	5-10 5-25
Tulalip Bay	0	4-20	0	5-10
Camano Head	288 2,800	4-27 5-5	659 4,320	4-26 5-8
Homes Harbor	36,131 75	4-21 4-28	786 2,083 858	4-27 5-11 5-24
Combined	10,730		1,495	

(continued)

Table 2 Marine pink and chum fry surveys in Puget Sound, 1964.

Area	Date	Miles surveyed	Total fish per mile	Pinks per nautical mile	Per cent pinks	Chums per nautical mile	Per cent chums
SOUTH PUGET SOUND							
Dana Passage (Bays)	5-8	0.75	11,847	0	0	11,847	100
Henderson Inlet	5-8	0.63	1,778	0	0	1,778	100
Steamboat Island	5-18	0.50	210	0	0	210	100
Case Inlet	5-19	5.00	447	0	0	447	100
Johnson Pt.	5-8	0.25	1,200	0	0	1,200	100
	5-19	0.50	6,400	0	0	6,400	100
	5-25	0.25	9,350	-	-	-	-
Nisqually	5-8	0.33	13,365	-	-	-	-
Longbranch vic.	5-19	1.75	1,929	0	0	1,929	100
	5-25	3.00	1,148	0	0	1,148	100
Anderson Island	5-19	5.00	40,000	0	0	40,000	100
	5-25	1.50	980	-	-	-	-
Steilacoom	5-8	0.50	2,410	0	0	2,410	100
Fox Island - south side	5-25	0.50	4	-	-	-	-
Hale Passage	6-1	2.05	5,854	702	12	5,152	88
So. Tacoma Narrows	6-1	0.50	±2,000,000	240,000	12	1,760,000	88
Gig Harbor	6-1	1.00	6,635	200	3	6,435	97
Maury Island	6-3	1.75	723	-	-	-	-
Quartermaster Hbr.	6-3	0.83	759	-	-	-	-
West Pass	6-3	1.13	4,442	-	-	-	-
WEST PUGET SOUND							
Blake Island	6-12	2.5	4,594	-	-	-	-
Manchester	6-12	2.0	5,000	-	-	-	-
Rich Passage	6-12	1.0	15,000	-	-	-	-
Port Orchard	6-11	4.25	3,520	-	-	-	-

Table 2 Marine pink and chum fry surveys in Puget Sound, 1964 (continued)

Area	Date	Miles surveyed	Total fish per mile	Pinks per nautical mile	Per cent pinks	Chums per nautical mile	Per cent chums
WEST PUGET SOUND (continued)							
Liberty Bay	6-11	3.25	3,870	-	-	-	-
Agate Pass	6-11	0.75	333	-	-	-	-
Port Madison	6-11	1.5	1,410	-	-	-	-
STILLAGUAMISH - SNOHOMISH AREAS							
Point No Point	6-3	1.0	485	-	-	-	-
Possession Point	5-5	1.0	710	710	100	0	0
	5-11	0.15	12,833	-	-	-	-
	6-3	1.35	733	-	-	-	-
Mukilteo south	5-11	0.25	1,600	-	-	-	-
	6-3	0.70	321	-	-	-	-
Everett south	5-11	0.37	27	-	-	-	-
	6-3	0.20	50	-	-	-	-
Columbia Beach (and vicinity)	5-5	0.75	6,133	-	-	-	-
	5-11	1.25	30,528	30,528	100	0	0
	6-3	0.20	375	-	-	-	-
Hat Island	4-21	0.50	96,000	69,120	72	26,880	28
	4-27	1.25	4,240	3,477	82	763	18
	5-5	1.00	505,165	454,648	90	50,516	10
	5-18	0.37	2,432	-	-	-	-
	6-2	0.75	567	-	-	-	-
Tulalip Bay	4-20	1.0	0	0	0	0	0
Port Susan	4-20	5.0	120	-	-	-	-
	5-5	2.75	5,309	4,778	90	531	10
	5-19	0.25	0	0	0	0	0
Camano Head	4-27	2.25	1,600	1,312	82	288	18
	5-5	1.50	28,000	25,200	90	2,800	10
Elger Bay	4-16	0.50	100	-	-	-	-
	5-4	1.00	50	-	-	-	-
Sandy Point to Holmes Harbor	4-21	0.75	1,200	-	-	-	-
	4-28	0.25	800	-	-	-	-
	5-4	1.12	5,805	-	-	-	-
	5-18	0.50	6,000	-	-	-	-

Table 2 Marine pink and chum fry surveys in Puget Sound, 1964 (continued)

Area	Date	Miles surveyed	Total fish per mile	Pinks per nautical mile	Per cent pinks	Chums per nautical mile	Per cent chums
STILLAGUAMISH - SNOHOMISH AREAS (continued)							
Holmes Harbor	4-7 to 4-21	2.75	225,818	189,687	84	36,131	16
	4-28	0.40	1,250	1,175	94	75	6
	5-4	0.87	517	-	-	-	-
	5-18	0.75	52,533	-	-	-	-
Holmes Harbor to Snatelum Point	4-16	2.15	13,140	-	-	-	-
	5-19	0.55	7,055	5,291	75	1,764	25
SKAGIT - NOOKSACK AREAS							
Penn Cove	4-16	0.87	140	-	-	-	-
	5-19	1.25	1,736	1,302	75	434	25
	6-11	1.50	540	-	-	-	-
Polnell Point	4-28	0.40	3,560	-	-	-	-
	5-11	0.90	555	-	-	-	-
	6-11	0.75	400	-	-	-	-
North shore Camano Island	4-16	1.75	1,592	-	-	-	-
	5-11	1.00	0	-	-	-	-
	5-19	1.25	57,604	-	-	-	-
Swinomish Slough	4-23	1.50	970	-	-	-	-
	5-1	1.50	133	125	94	8	6
	5-5	5.40	941	583	62	358	38
	5-15	0.75	3,267	-	-	-	-
Hope Island	4-7	2.12	7	-	-	-	-
	4-14	1.00	0	-	-	-	-
	4-23	3.25	1,655	1,341	81	314	19
	5-11	1.50	900	-	-	-	-
	5-15	0.65	2,692	-	-	-	-
Inside Deception Pass	4-7	1.50	2,017	2,017	100	0	0
	4-14	3.05	68,197	51,148	75	17,049	25
	4-23	2.10	355	337	95	18	5
	4-28	1.0	1,000	-	-	-	-
	5-11	2.0	14,750	11,653	79	3,098	21
	5-15	1.35	12,241	10,772	88	1,469	12
	6-9	1.50	410	-	-	-	-
	6-23	1.50	905	543	60	362	40
	6-28	1.85	2,054	-	-	-	-

Table 2 Marine pink and chum fry surveys in Puget Sound, 1964 (continued)

Area	Date	Miles surveyed	Total fish per mile	Pinks per nautical mile	Per cent pinks	Chums per nautical mile	Per cent chums
SKAGIT - NOOKSACK AREAS (continued)							
Outside Deception Pass	4-7	0.30	33,667	33,667	100	0	0
	4-14	0.25	0	0	0	0	0
	5-15	0.85	8,882	7,816	88	1,066	12
	6-23	0.50	20,000	20,000	100	0	0
	6-28	0.50	6,290	-	-	-	-
Burrows Bay	5-3	2.50	0	-	-	-	-
	5-15	0.25	0	-	-	-	-
	6-23	5.00	11,585	11,585	100	0	0
Allen Island	5-15	0.25	49,600	49,600	100	0	0
Guemes Channel	4-9	4.00	12	-	-	-	-
	5-15	3.35	1,552	-	-	-	-
	6-15	1.75	17,991	17,091	95	900	5
	6-29	3.50	3,014	-	-	-	-
March Point	4-16	0.50	0	-	-	-	-
	4-27	0.25	520	-	-	-	-
	5-15	0.50	1,600	-	-	-	-
	6-9	0.50	210	-	-	-	-
E. Guemes Island	5-14	1.00	0	-	-	-	-
Cypress & Sinclair Islands	5-14	1.00	9,765	-	-	-	-
Samish Bay	4-21	0.50	3,000	-	-	-	-
	4-28	1.50	53	-	-	-	-
	5-12	0.25	0	-	-	-	-
	5-14	0.50	2,000	-	-	-	-
Bellingham Bay	4-21	1.50	1,083	-	-	-	-
	4-28	0.75	200	-	-	-	-
	5-12	0.50	0	-	-	-	-
	5-14	0.50	0	-	-	-	-
	6-12	3.40	0	-	-	-	-
Birch Bay	4-28	4.50	0	-	-	-	-
HOOD CANAL							
Pleasant Harbor	4-23	0.37	31,081	9,013	29	22,068	71
	5-1	0.25	40,000	11,600	29	28,400	71
Jackson Cove	4-23	0.37	1,081	-	-	-	-
	5-14	0.45	18,890	-	-	-	-
	5-28	0.10	25,000	-	-	-	-

Table 2 Marine pink and chum fry surveys in Puget Sound, 1964 (continued)

Area	Date	Miles surveyed	Total fish per mile	Pinks per nautical mile	Per cent pinks	Chums per nautical mile	Per cent chums
HOOD CANAL (continued)							
Quilcene Bay	4-23	0.10	0	-	-	-	-
	5-9	0.45	2,182	65	3	2,117	97
So. Coyle Peninsula	4-24	0.25	4,600	-	-	-	-
	5-1	0.25	10,000	3,800	38	6,200	62
	5-14	1.25	18,880	8,307	44	10,573	56
	5-28	.75	39,833	-	-	-	-
Seabeck to Bangor	4-24	0.10	1,000	-	-	-	-
	5-14	0.10	50,000	16,500	33	33,500	67
	5-28	1.10	12,000	-	-	-	-
Floating Bridge - Port Gamble	4-24	0.10	250	-	-	-	-
	5-2	0.45	3,462	-	-	-	-
	6-5	2.00	6,047	4,051	67	1,996	33

five criteria, including slow growth and low food supply, as direct indicators of stock strength, citing Amur River autumn chum salmon (Oncorhynchus keta) as an example.

Pink salmon (O. gorbuscha) become important to marine anglers near Cape Flattery during July, approximately a month before they are more than incidental in Puget Sound commercial net catches and two months before this net fishery peaks. There has been a 4.3 cm annual variation in the average fork lengths of July sport-caught pink salmon sampled on western Juan de Fuca Strait from 1957 through 1965. These differences have varied inversely with the magnitudes of pink salmon immigrations to the International Pacific Salmon Fisheries Commission Convention Area. The extreme annual July length variations, from 1959 through 1965, occurred in 1961 and 1963 (Figure 2) relationships between "stock size" and the average lengths sampled in July. Stock size is herein defined as the total (in numbersof pinks) of, (1) Canadian catch from IPSFC convention waters, (2) Washington State catch, (3) Fraser River escapement, and (4) the Puget Sound tributary escapement. The 1957 Puget Sound tributary escapement was unknown, but it is herein estimated to be 1.0 million. The curve in Figure 3 was fitted by eye.

In recent years of low pink salmon abundance, there has been an obvious discrepancy between published maximum weights of pink salmon and weights of locally caught fish. During 1959, when the Washington cycle-year catch descended to an unprecedented level, pinks exceeding ten pounds round weight were relatively common. Ten pounds has been given as the maximum weight of pink salmon (Clemens and Wilby, 1961; Rounsefell, 1963). Berg (1948) is more conservative, giving a maximum total length of 680 mm (approximately 640 mm fork length) and a maximum weight of 3,194 (7.0 lb).

It would appear that pink salmon depends upon a complexity of environmental factors. Nevertheless, by July 22, 1965, on the basis of lengths of pink salmon taken near Cape Flattery from June 29 through July 10, 1965 and a very low catch per unit of effort, we suggested that the 1965 run would be of the same magnitude as occurred in 1961. The final average fork length for July 1965 sport-caught pink salmon from western Juan de Fuca Strait was 58.6 cm. This length corresponds to a stock strength of 3.4 million when related to the previously established trend line (Figure 3). The latest information available to us indicates the 1965 stock size was about equal to that of 1961.

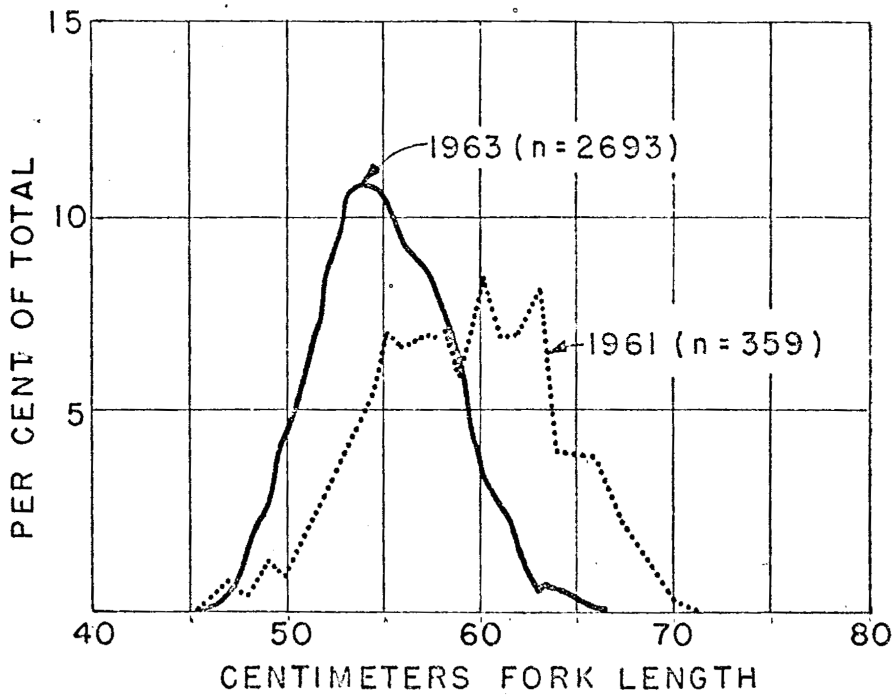
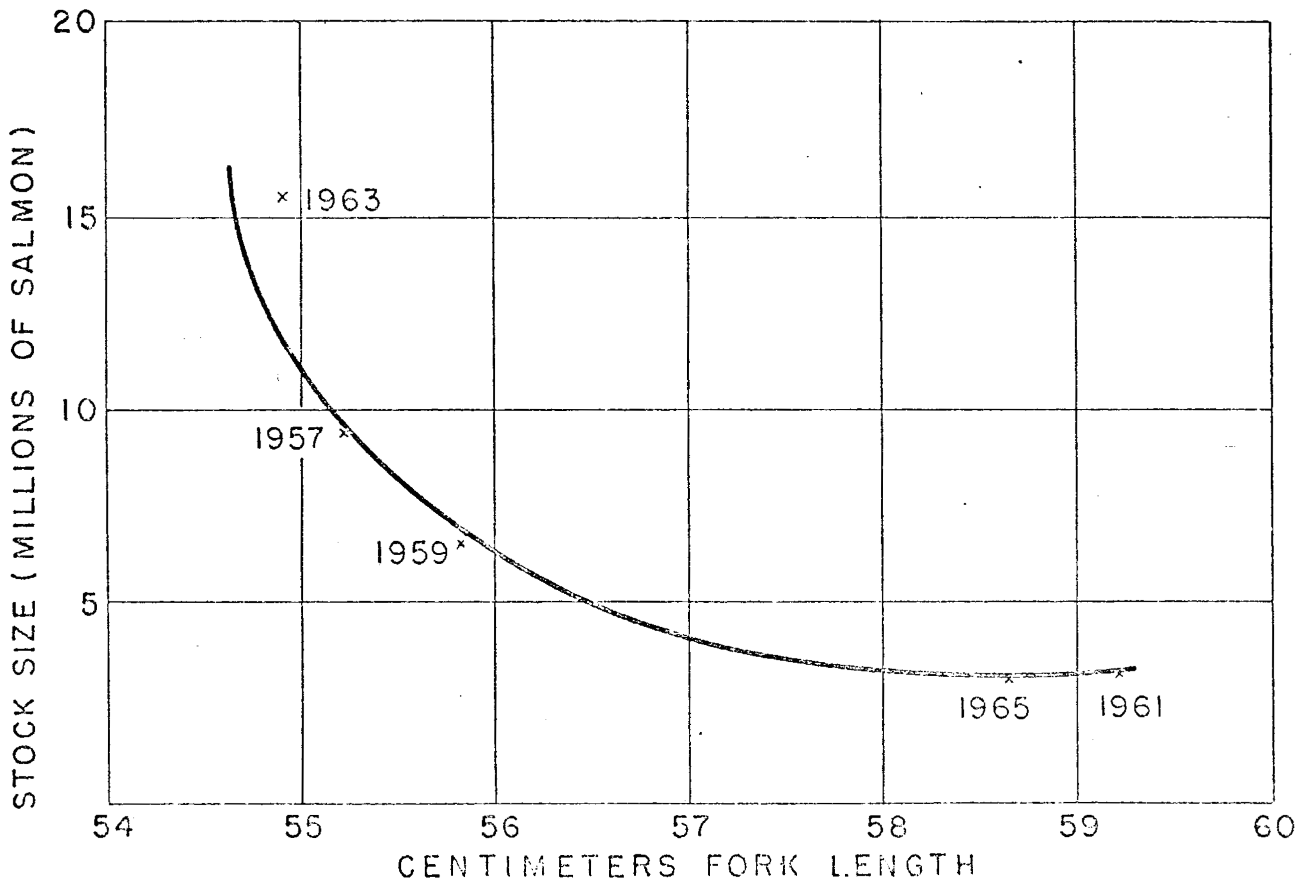


Figure 2. Length frequencies of July sport-caught pink salmon sampled in 1959 and 1963 from western Juan de Fuca Strait.

Figure 3. Relationships of the average July lengths of sport-caught western Juan de Fuca Strait pink salmon to stock size (1957 through 1965).



July sport catches per unit of effort, although somewhat anomalous, may be of prognastic value (Figure 4).

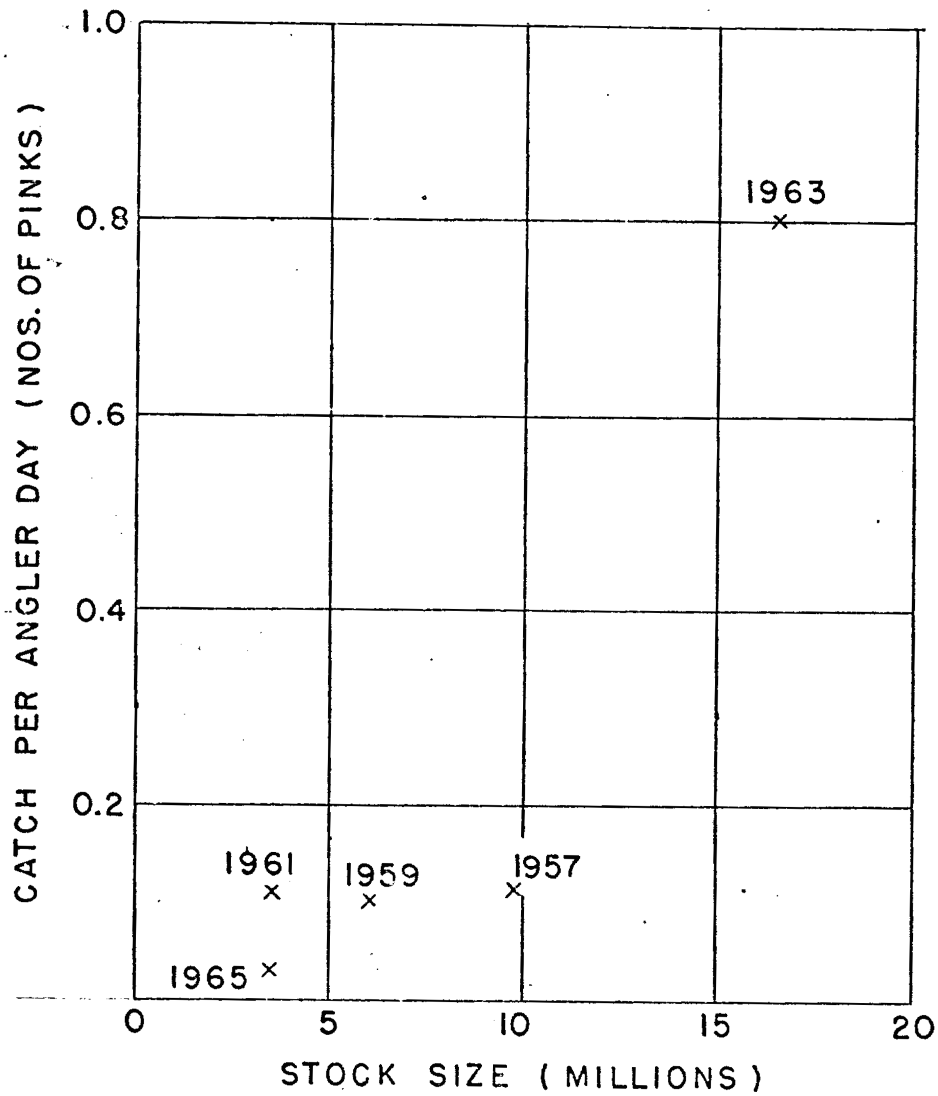


Figure 4. Relationships of average sampled July western Juan de Fuca Strait catches per unit of effort to stock size (1957 through 1965)

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DISCUSSION

Mr. Martin: In connection with the idea that the smaller the fish the larger the run and vice versa, I tried to show that the relationship between various segments of the run can very strongly influence the size of the fish taken. My hypothesis is that the overall rate of growth is related to rate of growth in estuaries and coastal waters. Cooler water may be more conducive to survival than warmer water.

Mr. Jewell: In 1964 we had, in Puget Sound, an extremely wet, cold summer followed by the lowest return of pink salmon recorded.

Dr. Salo: What have returns to Hoodsport, where fish were reared in salt water past the so-called critical stage, been in the past few years?

Mr. Jewell: In 1965 the return was very poor, about 430; in 1963 the return was 9,600; in the two cycles previous to 1963 the return was two to three thousand. With the exception of 1965, returns have been similar to general abundance of pinks in Puget Sound. Regarding 1965 we predicted several areas that would have poor returns. From the Nooksack south to the Skagit, Stillaguamish and Snohomish Rivers serious flash floods occurred. There was over-escapement in the Nooksack and good escapement in other streams. In the Hood Canal area there was no flooding, but over-escapement in two of the major streams, the Dungeness and the Dosewallups. The latter streams got the largest returns in 1965. In some other streams around Hood Canal and the Olympic Peninsula escapements were almost as good as in 1963. So far this year we have had no flash flooding, no serious freezing.

EARLY SEA LIFE OF PINK SALMON

John Wilson Martin, Bureau of Commercial Fisheries, Auke Bay

Studies of the early sea life of pink and chum salmon were initiated in Auke Bay in 1962; in lower Chatham Strait in 1963; and extended throughout southeast Alaska in 1964 and 1965 as part of the Bureau's long-range pink and chum salmon research program. The purpose of these studies has been to obtain information for planning more comprehensive investigations into this little known period in the life history of pink and chum salmon.

Operations are based on the 58-foot research vessel M/V HERON and BLUE BOAT, a 20-foot high-speed reconnaissance-catcher vessel which conduct cruises throughout southeast Alaska each year. M/V HERON is equipped as a mother-ship with shipboard laboratory for processing biological information, plus equipment for monitoring the sea-surface environment. BLUE BOAT, is equipped with a bow steering station for observations and fishing operations with a 100-fathom small fish round haul net, and ranges throughout study areas at high speed, while HERON proceeds between stations at 10 knots. Cruises beginning in May range from 8 to 12 days in duration at intervals until September. Personnel include two scientists, a vessel operator-technician, and a temporary assistant.

Biological investigations which complement the cruises include: holding pens in saltwater, in which fry from nearby Auke Creek are held each year under comparable conditions; controlled saltwater temperature tanks in the laboratory for temperature-growth and survival studies; and parasite studies by a part-time parasitologist.

Pink Salmon Migration Timing

Pink salmon fry migrations into saltwater, begin in late March and extend into June. Time of peak migration differs widely between geographic areas. Early migrants attain significantly greater size by the time late migrants enter estuaries. Length-frequencies of mixed stocks of juvenile salmon captured during the summer show differences which indicate length of time in saltwater and, consequently, geographic origin in southeast Alaska.

Southeast Alaska pink salmon fall into three categories, based on timing of adult migrations through the commercial fishery and into home streams; spawning, egg and larval development, and juvenile downstream migrations into estuaries during the following spring. The three categories are:

1. Early runs - spawn in larger mainland snow-fed streams before August 15 (fry migrate into estuaries before May 1).

2. Middle runs - spawn in streams having characteristics of both early and late streams, before September 15. Streams often have lake systems (fry migrate into estuaries before May 15).

3. Late runs - spawn in coastal island streams, usually dependent upon precipitation, after September 15 (fry migrate into estuaries after May 15).

Southeast Alaska adult pink salmon abundance differs in timing between the northern and southern divisions. These two divisions are separated geographically by a line running through Kuiu, Kupreanof and Mitkof Islands, midway between Juneau and Ketchikan. Abundance in the northern division is based on productive early run streams supported by a fairly productive, but variable group of middle run streams. The southern division (which produced record pink salmon catches in 1934, 1936 and 1941) is predominantly a late run area supported by early and middle run streams comparable to the northern areas. Commercial fishery records for the northern division show early fishing in Icy Strait by mid-June progressing with the runs toward Frederick Sound, Stephens Passage, and ending before mid-August with middle runs in lower Chatham and Peril Straits. Southern division fishing beginning in mid-July, usually reaches a maximum production in late August. These timing differences have been reflected in spawning ground surveys and in timing of downstream migrations.

Early Marine Growth of Juvenile Pink Salmon

Pink salmon fry enter saltwater earliest in early run streams in April, generally in estuaries characterized by cold conditions. Migrants entering from late run streams in May and early June are in an environment characterized by warmer water and abundant food in the coastal and island estuaries.

Collection of fry growth information when spring saltwater temperatures are rising was needed, so we began growth rate studies in Auke Bay in 1962. Using floating live-boxes in saltwater, fry were taken at intervals from Auke Creek and held for periodic measurement of growth for the same fish.

Pen experiments in Auke Bay (Figure 1), April 1 - May 20, showed increased growth rates as surface temperatures increased. Relative growth among all experiments remained the same after May 20. Early and late migrants retained their relative size differences. Similar differences in growth and size were observed in comparable pen experiments, 1963, 1964, and 1965, and among wild fish throughout southeast Alaska in 1964 and 1965.

Decreased growth rates occurred in all experiments in 1962 (Figure 1) after mid-June when temperatures continued to rise above those associated with wild fish. Comparable experiments in 1963 (when lower summer temperatures occurred in Auke Bay) were characterized by more consistent growth during a similar period and suggested two hypotheses for laboratory testing:

1. Food levels or composition were changed by time of season or rising temperatures and restricted growth.

2. Warm summer saltwater temperatures, not associated with wild fish, restricted growth.

Pink salmon fry taken during the downstream migration in 1964 and 1965, were reared in tanks with controlled saltwater temperature. Saltwater pumped from Auke Bay from a depth of 120 feet was filtered through a plankton net into the first tank. Water from the first tank cascaded by gravity flow through five more tanks set at successively lower levels with immersed standard heating coils to raise each tank temperature by several degrees Celsius. Constant temperatures were maintained by regulation of input water flow. In initial experiments fish were fed equal quantities of live zooplankton from Auke Bay. In later experiments fish were fed frozen brine shrimp (*Artemia salina*), frequently in excess of apparent needs. Using a photographic technique developed in 1962 for repeated measurements of live juvenile pink salmon, fish were measured periodically for growth over a range of saltwater temperatures. Results for 1965 (Figure 2) show rapid growth between 11°C and 16°C with maximum growth between 13°C and 14°C. Salinities remained about 31 o/oo during the experiments.

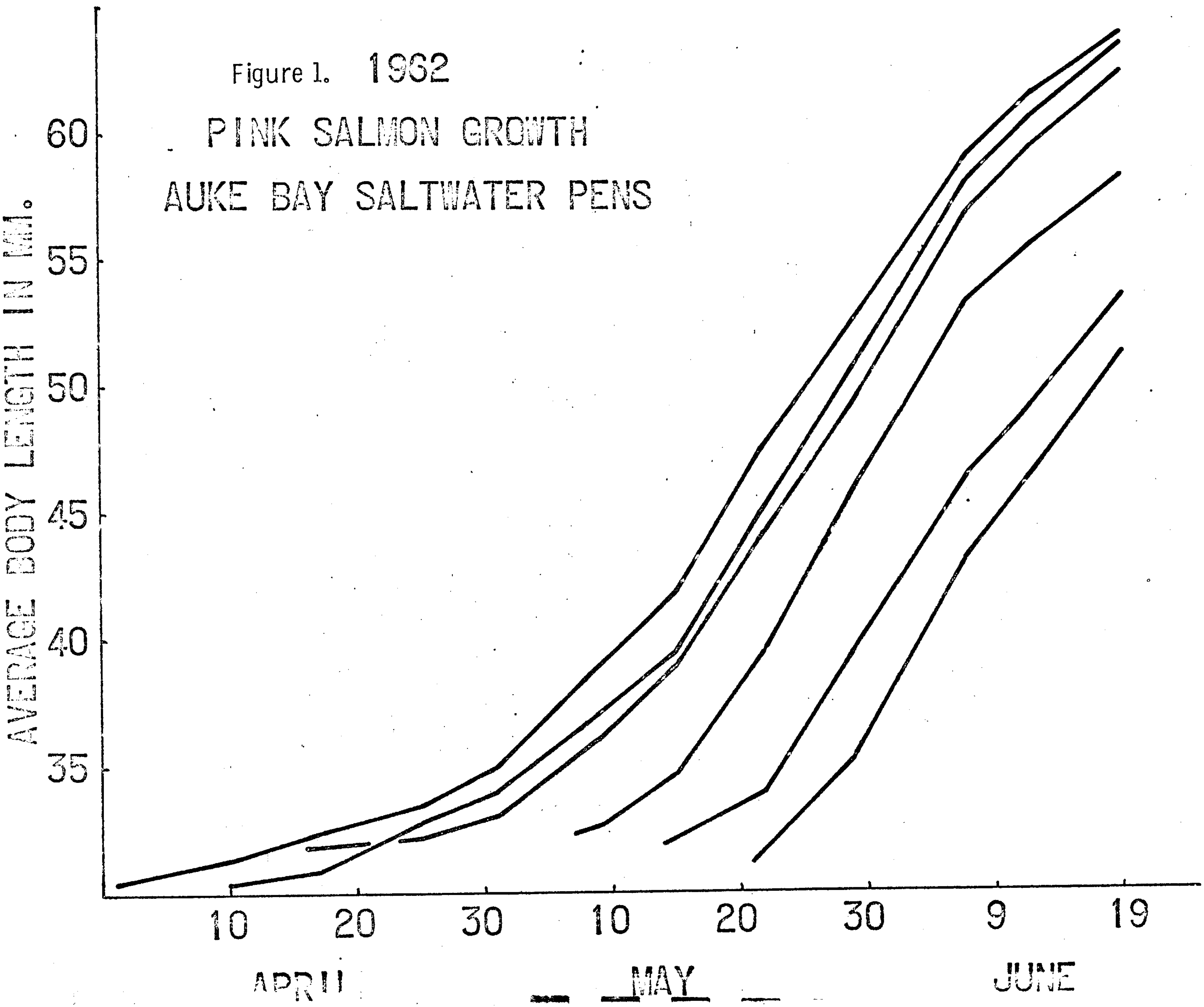
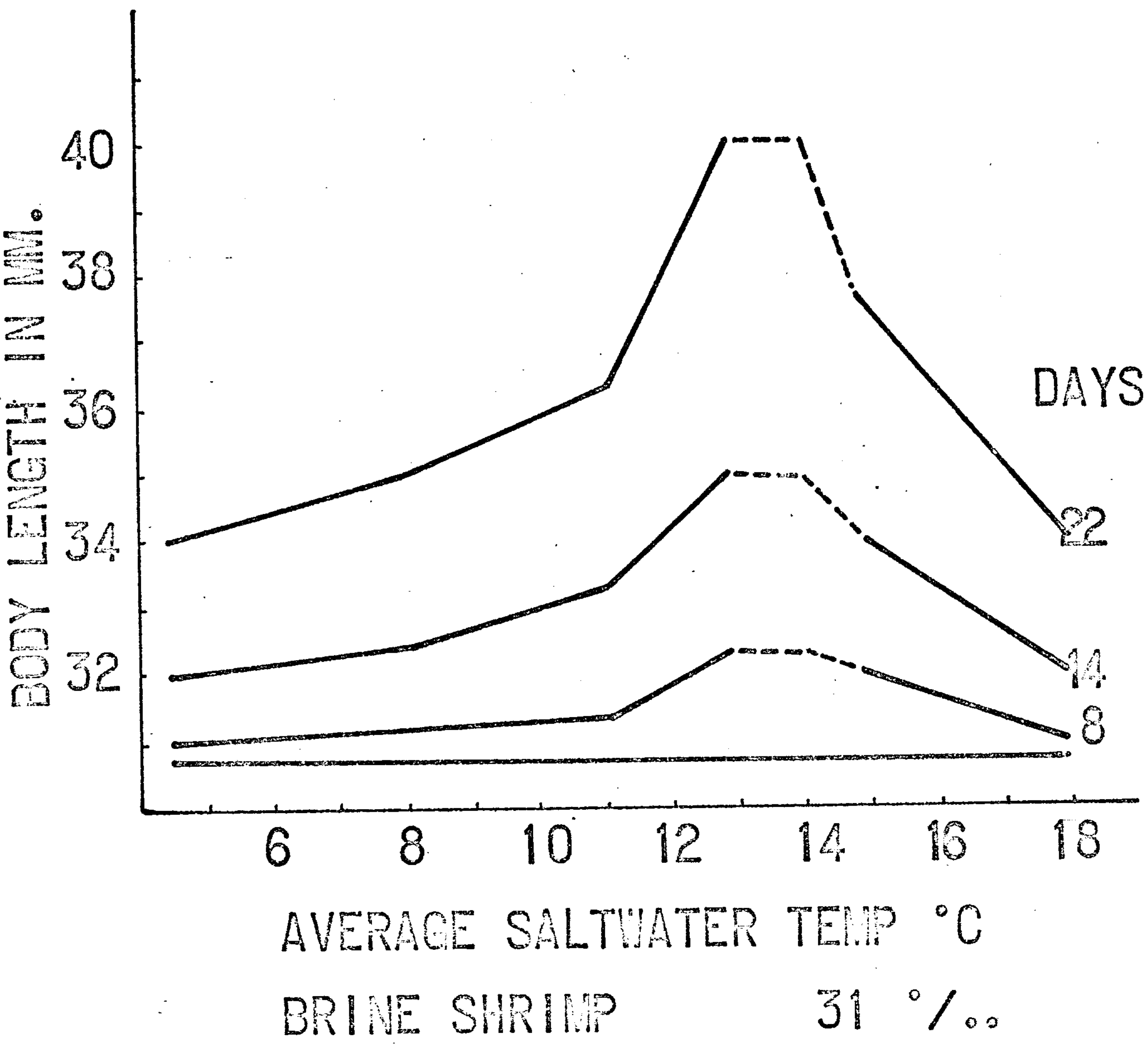


Figure 1. 1962
PINK SALMON GROWTH
AUKE BAY SALTWATER PENS
AVERAGE BODY LENGTH IN MM.
60
55
50
45
40
35
10
20
30
10
20
30
9
19
APRIL
MAY
JUNE

Figure 2. 1965

PINK SALMON

TEMPERATURE - GROWTH



Early spring observations of fish and plankton measurements, plus experimental results, do not support the popular hypothesis that food may be a major factor limiting early marine growth of juvenile pink salmon. Early marine saltwater temperatures (which vary from year to year) are a major factor in determining growth rates of juveniles. My observations throughout southeast Alaska in 1964 and 1965 showed that juvenile pinks averaged 2 cm longer in 1964 when summer sea-surface temperatures exceeded by 3° C - 5°C those following the record cold winter of 1964-1965. Major concentrations of pinks were not observed in either years in areas where surface temperatures approached maximum growth temperature ranges found in the laboratory.

Inshore and coastal environmental conditions are more variable than the open ocean from year to year. Our growth studies suggest a hypothesis that variable size of juveniles entering the Gulf of Alaska may be reflected in size of returning adults. Previous studies by other investigators do not show relationships of adult size to size of migrants. We believe that relative strength of early and late runs could obscure relationships using seasonal averages for size of adults .

Average weekly size of pink salmon for the Icy Strait fishery in the northern division of southeast Alaska, and for the fishery around Ketchikan in the southern division for 1965 (Figure 3) show late fish to be larger. Northern division runs are primarily early and the seaward migrants entered the Gulf in 1964 and 1965 at about the same size each year (Figure 4). Final ocean growth differences between early and late fish in Icy Strait in 1965 is a logical explanation for progressive increase in size of fish which went to sea at about the same size. Dominance of late run pinks in the southern division could over-shadow smaller early run fish in the commercial fishery and account for the minor increase in size in 1965.

Information on size of fish in the commercial fishery is limited and precludes more detailed analysis. However, our information indicates that seasonal averages for size are probably influenced by strength of early and late runs which prevents relating annual and long-term variations to environmental factors. For example, the years in which early runs were abundant in the commercial fishery could have produced an average size less than that in other years. Since early runs appear to be more variable, poor runs usually were dominated by late fish which probably were larger in size.

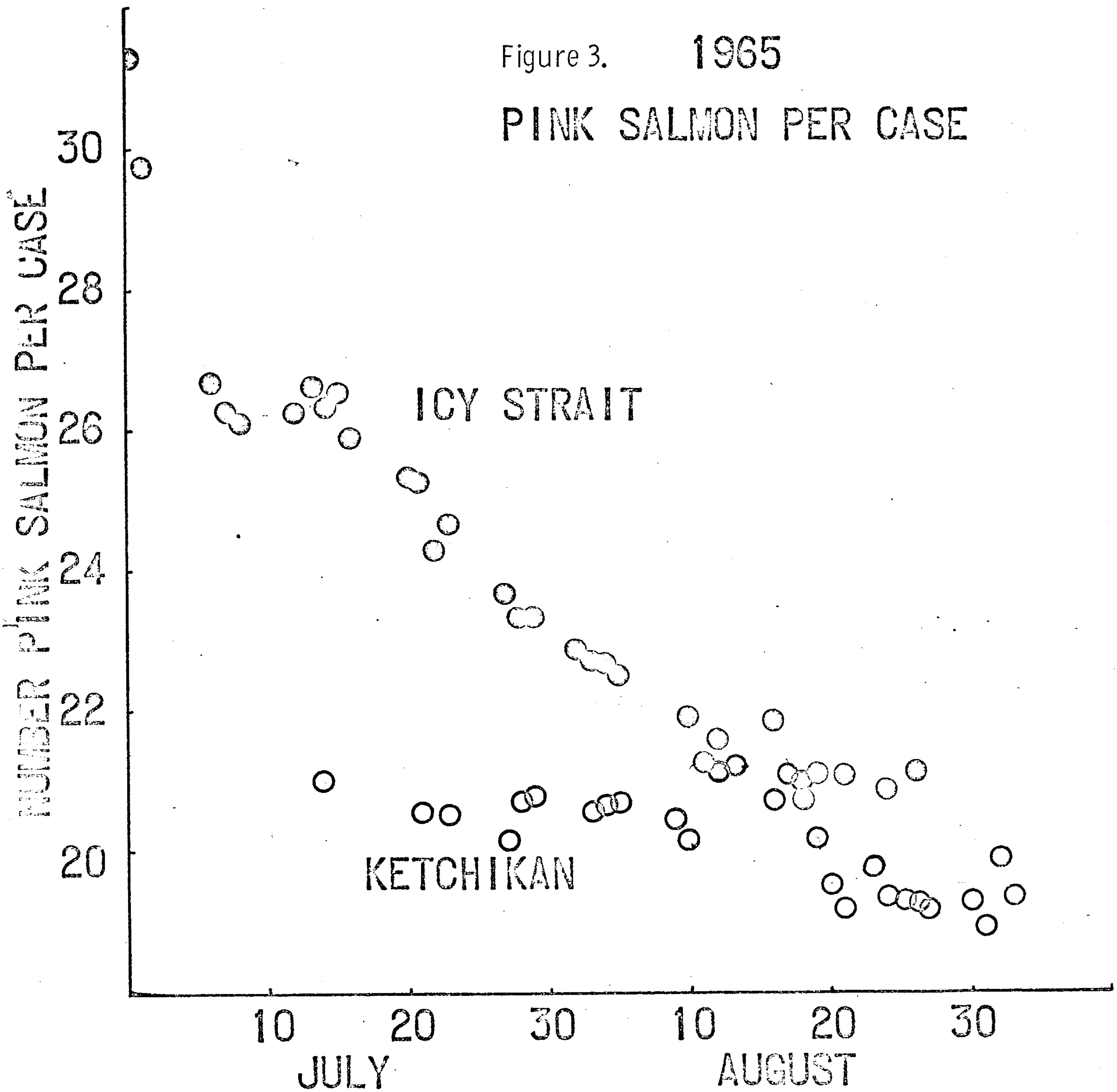


Figure 3.
1965
PINK SALMON PER CASE
NUMBER PINK SALMON PER CASE
30
28
26
24
22
20
ICY STRAIT
KETCHIKAN
10
20
30
10
20
30
JULY
AUGUST

Figure 4. Sample length-frequencies of southeast Alaska pink salmon, 1964-1965.

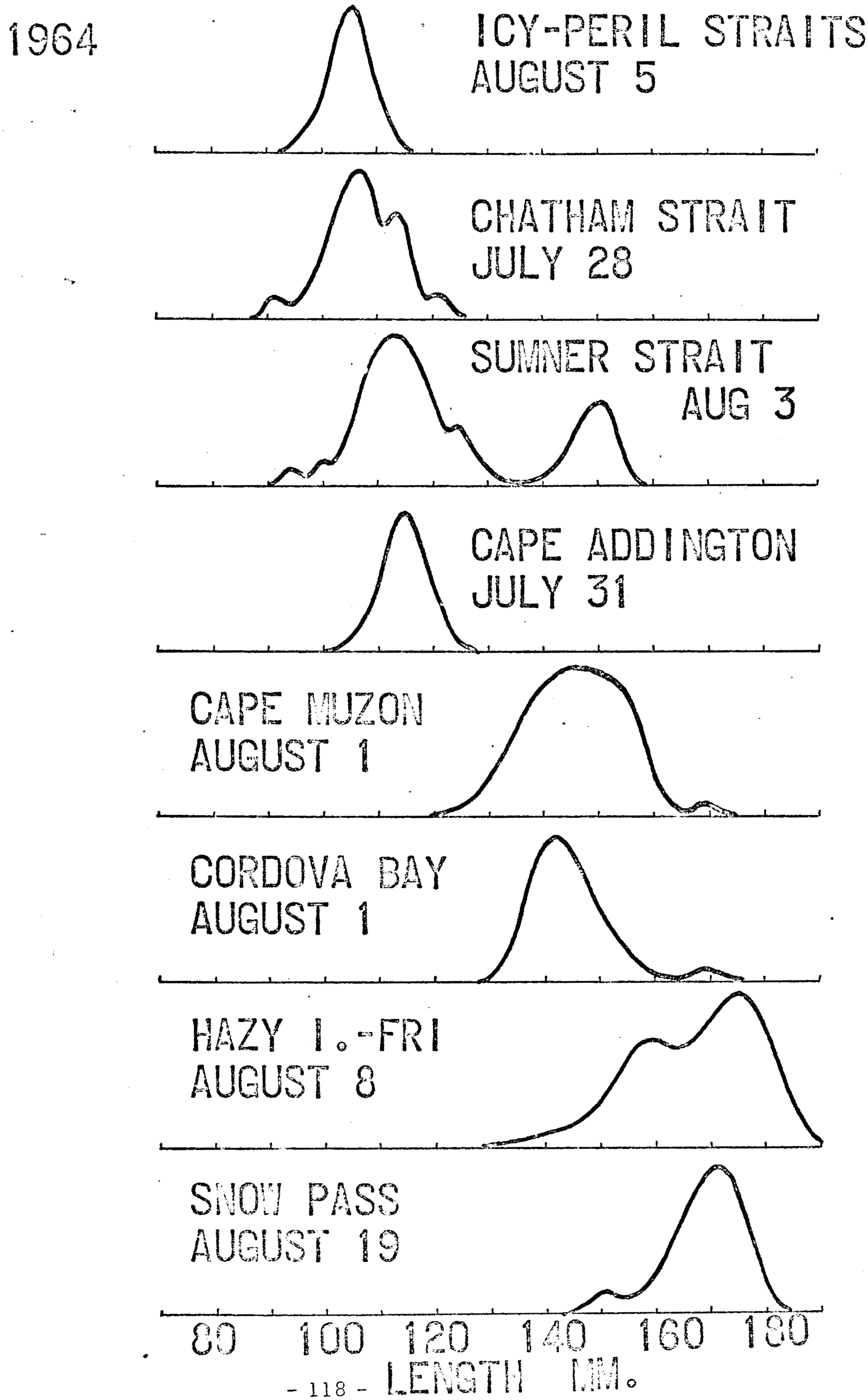
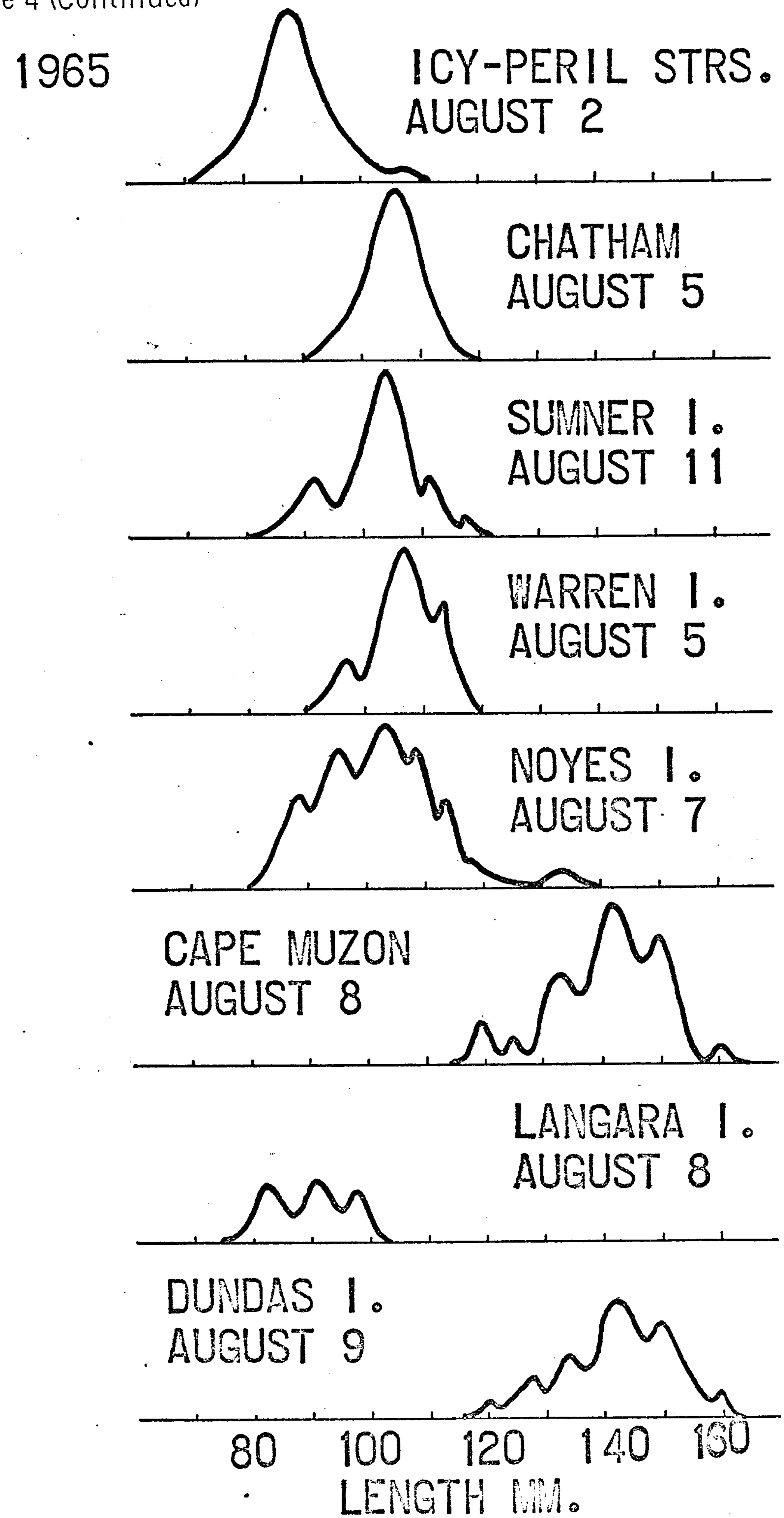


Figure 4 (Continued)



Size of seaward migrant pinks in 1965 for various areas in southeast Alaska (Figure 5) averaged 2 cm less in 1964. Abundance of juveniles in the northern division observed in 1965 was considerably less than in 1964. We are forecasting pink salmon runs into the Icy Strait fishery in 1966 that will be considerably less than in 1965, a mediocre year. To test the hypothesis that size of fish is not density-dependent but determined by size of juveniles entering the Gulf, we are forecasting that the low level of abundance of pinks forecast for Icy Strait will also be below average size.

Migrations and Distributions of Juvenile Pink Salmon

Major migrations of juvenile pink salmon from estuaries into main channels occur in May. Early stream migrants which enter saltwater during April generally accumulate in estuaries near home streams until May. Late migrants entering saltwater generally remain in estuaries for only a few days before leaving for main channels. Spring surface temperature rise from about 5°C to 9°C in Auke Bay from 1962 to 1965, corresponded to migrations out of the bay. Falling surface salinities associated with spring run-off vary among estuaries and have not shown changes of comparable magnitude.

Migration routes of juvenile pinks in southeast Alaska correspond to our estimates of net surface water transport toward the Gulf, based on temperature-salinity profiles, current measurements, and drift observations. Changed routes of migrants in several areas in 1964 and 1965, were related to prevailing winds which correspond to direction of migrations. Most migrations observed in southeast Alaska followed routes leading to major summer schooling areas (Figure 6). Not shown are numerous minor schooling areas which were collection points along migration routes. Areas in the southern division were inter-related with progressions of fish observed moving from one area to the next enroute to the Gulf.

Peak migrations in southeast Alaska in 1964 and 1965 were observed during the end of July and the first part of August when major migrations of juvenile pink salmon entered the Gulf from Sumner Strait and Chatham Strait. Smaller migrations entered from Icy Strait, Peril Strait and north of Noyes Island. Migrations of large juvenile pinks, originating outside of southeast Alaska, moved into the Gulf about the same time through north Dixon Entrance with a secondary route around the north end of Dall Island through Tlevak Narrows.

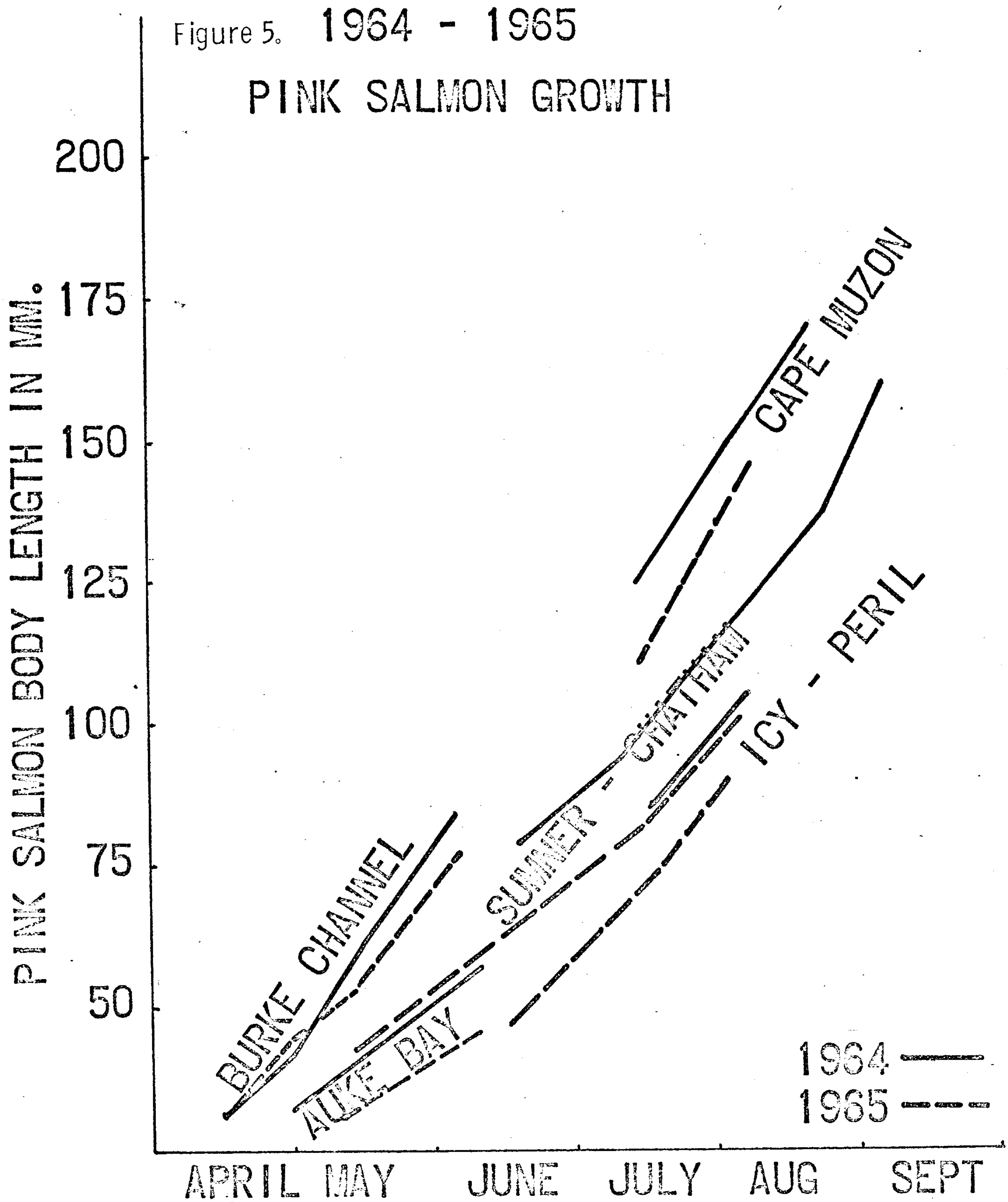


Figure 5. 1964 - 1965
PINK SALMON GROWTH
PINK SALMON BODY LENGTH IN MM.
200
175
150
125
100
75
50
CAPE MUZON
ICY - PERIL
SUMNER - CHATHAM
BURKE CHANNEL
AUKE BAY
1964
1965
APRIL
MAY
JUNE
JULY
AUG
SEPT

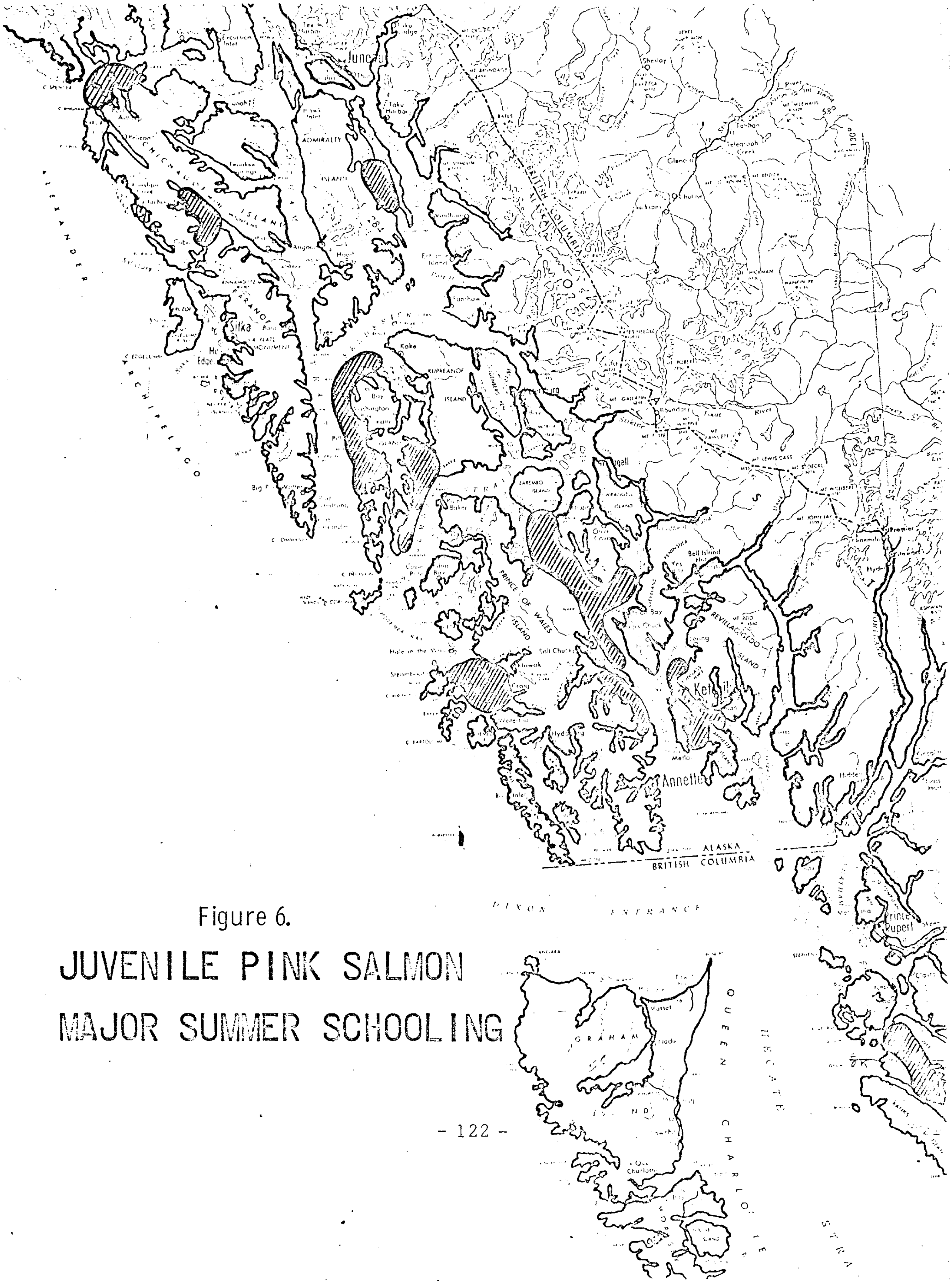


Figure 6.
JUVENILE PINK SALMON
MAJOR SUMMER SCHOOLING

Migration behavior of juveniles is comparable during the initial move out of estuaries and during the final stages of their move into the Gulf. Both period are marked by a definite effort to leave the previous area by utilizing ebb currents and holding close to shore, near kelp, in coves, or in bay mouths during flood tides. Movements across bay and cove mouths along migration routes appears to be aided by ebb currents from these tributary arms. Fish have been frequently observed accumulating along convergences at these points and following the channel side until the opposite shore has been reached. Rates of migration observed for late Gulf migrants in September 1963, in Chatham Strait increased from 3-4 miles per day to over 10-12 miles per day during a two-week period beginning at the end of August about 50 miles from the Gulf. Numbers of fish in schools increased considerably over looser feeding groups observed in summer schooling areas. Feeding activities were visible for a mile with many jumpers and surface swirls observed. The rapidly growing fish, ranging from 120 to almost 200 mm in body length, were observed during migrations across major channels. Fish examined from cross-channel termination points often had little or no food in their stomachs. Other fish captured leaving these points were feeding vigorously and generally had full stomachs. Prior to entry into the Gulf, fish were seldom found out of shore contact for long periods. Fish observed entering the Gulf from major entrances with abundant food were not migrating as a result of scarcity of food.

Juvenile Pink Salmon Migrations in Dixon Entrance

Proximity of Naas-Skeena river systems in northern British Columbia led us to expect intermingling of juvenile pink salmon from both countries in American waters adjoining Dixon Entrance. Striking differences in size were first noted in 1964 when we found unexpectedly large juveniles among our catches in the Ketchikan area. In 1965, we extended our spring sampling into northern B.C. to determine growth rates for comparison with American fish. Observations extended as far south as Napean Sound, about 100 miles south of our border. We found Canadian juveniles to be comparable to those in southern southeast Alaska. Distributions of Canadian juveniles comparable to ours showed progressions toward the north along the east side of Hecate Strait. Length-frequencies were indistinguishable from American stocks. However, on August 8, 1965, migrations of unusually large pinks were found actively moving west past Cape Muzon on the south end of Dall Island.

Surveys the same day along the north shore of Graham Island, B.C., produced catches of very small fish from the few schools observed. Many schools of pinks were seen that evening enroute past Rose Point at the entrance to Hecate Strait moving northwest toward the south end of Prince of Wales Island. Two marked pinks were captured August 9, 1965 in Caamano Passage, Dundas Island among 250 pinks with length-frequencies comparable to Cape Muzon (Figure 4). We now believe that an extension of the Hecate Strait current passes into the Gulf along the north side of Dixon Entrance and carries Canadian fish into the Gulf from as far south as central B.C. Absence of these large fish in Clarence Strait showed wind driven surface currents to be a factor in distributions of migration routes.

DISCUSSION

Mr. Tyler: In several of your pen experiments there was a decrease in growth rate in late spring. Do you attribute this to higher temperatures at that time?

Mr. Martin: Temperature more than food, because at the time there was no change in abundance of food, and only 10-25 fish per pen.

Mr. Tyler: In your pen experiments the fish were getting the same type of food the entire time. Different types of food may have been available in off-shore waters, but it wasn't available to your penned fish. Perhaps the preference of fish at that time for more open water might be a result of preference for a different type of food.

Mr. Martin: That hypothesis doesn't fit what we observed at Inian Islands, an area richer in euphasids than any we have discovered in the past two years. By the end of the second week of August the pinks all left the Inian Islands area and the euphasids remained. I consider the pen experiments valid through early June when the penned fish can still get the same type of food that the wild fish can. Coincident with the migration of the pinks from the inner bays there is a sharp rise in seawater temperatures (mid to late May). Early in the season the fish eat barnacle larvae, etc., later copepods and euphasids. I think this is because that type of food is available. For example, at Noyes Island, two sets were made about 200 yards apart. Fish from one set had been eating euphasids; fish from the other set had been eating copepods. Fish that I presumed to be actively moving across Hecate Strait and Dixon Entrance had nothing in their stomachs; yet fish presumably heading into the Gulf were loaded with copepods.

OPENING ADDRESS ON THE FUTURE OF PINK SALMON

Donald E. Bevan, University of Washington, Seattle

The things that concern us about the future of pink salmon fall into three different categories--the stocks, the product that comes from the stocks and the markets that receive the products. We have been successful in getting people here that certainly are the most knowledgeable on the subject. We are very fortunate in having the panel that is here today. Mr. Fredin has already shown that you have some interest in economics so I am not going to apologize for inviting economists; in fact, they paid their own way here which is an indication to me of how important they feel this audience is to them.

Let me start with the stock and what is going to happen to it. I wrote a rather long talk on what should happen based on our knowledge of forecasts but I discarded it before I cam to Ketchikan. I'll tell you why. I think we have a rather simple answer. I came to this conclusion after looking at the subjects on the agenda and the people who were going to talk. I came to what I think is a perfectly correct conclusion--that there should be no concern over the future of pink salmon. As a group we should acknowledge that we have the best brains available working on the problem. Pink salmon are in good hands. We are going ahead. We are going to have more pink salmon than some people will know what to do with. I am very optimistic because we have some guidelines now as to what optimum escapements should be. We have some idea of ways in which we can begin to make forecasts to reach these optimum escapements. As we refine this information, there is no direction but toward increased runs. With that, I'll dismiss the long-term future of stocks on a broad and cheery note. We all should be optimistic and convinced that we are doing our very best and I for one firmly believe it. John Gilbert has some things to say that will be of interest to you and without further ado, I'll turn the meeting over to Mr. Gilbert.

THE PINK SALMON INDUSTRY - OUTLOOK AND REQUIREMENTS

John R. Gilbert, Bumble Bee Seafoods, Seattle

As a representative of one company participating in the processing of pink salmon, I think that, with continuing progress toward fulfilling a number of complex requirements, the future is promising.

Please don't interpret what I have to say to be representative of the industry as a whole, for some may disagree, and all would express their outlook in different terms.

When I say that the outlook is promising, I am aware that many problems will beset the industry in the future, as they have in the past. I am using the term industry to include fishermen, processors, and workers. While it might be easier to speculate on these problems rather than speculate on reasons for optimism, there seems little need to buy trouble in advance.

Although the future looks promising, I don't want to imply that everyone will have a bonanza every year, or even that everyone or anyone will make money every year. However, commensurate with the growth of the resources I am confident that we will see continued growth in the ability to catch, process and bring to market in volume, a high quality pack which is attractive to the consumer.

This will not require any spectacular revolution in the facilities for catching, processing, or marketing pink salmon, but will take place as a continuing addition and improvement of the facilities and techniques we have. Perhaps the best way to measure this growth is in terms of what has taken place in recent history.

Few people credit to the industry the improvements, investments, and innovations which we have made in recent years. It is more popular to criticize us for our shortcomings. However, the adjustment made by the industry to the precipitous loss of fish traps in 1959 has been truly remarkable, considering the uncertain profit picture at that time.

The initial reaction to the loss of traps was to rebuild fishing effort by building and recruiting boats and increasing efficiency of those already in the fishery. This building and recruitment has now leveled off and the number of vessels is adequate.

Practically all of the boats in the major pink salmon fisheries are now equipped with power blocks, improved power skiffs, nylon nets, depth finders, radios, and many have radar and loran. I have no estimate of the investment value of these improvements, but the figure is enormous. The money has practically all been invested by independent fishermen and processors during the last ten years.

Another reaction to the loss of traps was to improve tenders and plants to try to offset the loss in product quality and plant efficiency. I have no accurate estimate of the number of refrigerated tenders now operating in the pink salmon fishery but I would guess that the minimum number is 75. Each of these represents an average investment of roughly $60,000 for refrigeration facilities alone. This investment of some 4-1/2 million dollars in no way reflects the replacement cost of these vessels nor the very high cost of maintaining this equipment.

Use of refrigerated sea water tenders has helped to raise the quality of the pack toward the high level of the trap era, although this former level has not yet been achieved. Conversion of tenders to refrigerated sea water will continue as capital permits and needs arise.

Considerable improvements have also been made in plant installations, through the use of refrigerated sea water and ice to help maintain freshness prior to processing. Major improvements have been made in handling, warehousing and shipping of the finished product, and some diversification of can sizes is evident. Although improvements will continue, don't expect the industry to dispose of good canning machinery to install revolutionary processing equipment. There is none available, and the developmental cost would be prohibitive.

I believe these recent efforts, investments and improvements, should be recognized and I feel they are the best gauge of what the future of the industry holds.

In order for the prognosis of a good future for the pink salmon industry to materialize, there are certain needs to be met in the future. I have grouped these industry needs according to primary responsibility of industry or government:

1. We need to continue to improve production of a high quality product with good consumer acceptance at realistic prices.

   a. This will require continuation of the improvements mentioned previously and also keeping pace with the latest advances in methods of fishing and processing.

   b. A realistic cost structure will have to be maintained within the industry in order for it to remain competitive. This will require maintenance of realistic costs for the raw product, labor and materials. It will also require an increase in efficiency of production. One area needing further development is the utilization of by-products; that is the marketing of eggs, oil and other parts of the salmon.

   c. While these are areas primarily of industry responsibility, we can be materially assisted by government through fisheries regulations which help to promote quality and efficiency, and technological research which helps to develop improvements in production techniques.

2. We need to continue aggressive marketing programs for the products by individual companies and industry wide programs of consumer education. In my opinion this is almost entirely an area of industry responsibility. Existing government consumer education programs have been and are appreciated, but I don't believe increased government involvement in this area is desirable. If money is available it can be put to better use in resource and technological research.

3. Improved transportation facilities and techniques of shipping products are evolving in Alaska and are instrumental to continued realistic costs within the salmon industry. They will be vital in allowing for by-product utilization and diversification of the industry from strictly a salmon base.

4. We need an improved business climate in the future. Our industry hasn't exactly an unblemished record of astute public relations in Alaska but I think we are making some progress. On the other hand, we have often been made a whipping boy when somewhat better treatment was deserved. Again, I hope improvements are coming in this respect, commensurate with the importance of the industry to Alaska. At least, some other industries are growing large enough that they can help share these responsibilities and rewards.

Perhaps the most important item of good business climate is to avoid excessive taxation of the industry. For many years we have carried a disportionate burden of the industry tax load in Alaska. At present the total of taxes paid usually exceeds the profits derived from the processing. Prospects are not bright that this burden will be eased and it may even grow at the local government level. Such excessive taxation is certainly not conducive to production of investment capital for the improvements which we will need. This is an area where government has absolute control over the future of the pink salmon industry.

5. We must continue to attract people with special skills into the industry. Perhaps this is primarily our responsibility, but government can assist by orienting school and labor training programs toward teaching these skills. Shortages of skilled mechanics and machinists in the canning machinery field may become acute in the near future.

In the foregoing I have tried to mention a few needs which, except where qualified, are substantially industry responsibility. I will close by citing several needs which are almost entirely the responsibility of government:

1. We need to maintain at least the present degree of protection of pink salmon stocks from exploitation by foreign fishermen. Other salmon, groundfish and shellfish species also need increased protection.

2. Increased knowledge of the pink salmon stocks, based on scientific research, which will allow management on the basis of maximum sustainable yield is essential to future growth of the industry. Probably before this complex goal is achieved (and as an essential part of attaining it) we will need accurate forecasts of abundance of returning runs by major stocks.

3. The pink salmon resources will need increased protection from deleterious effects of other uses of the watersheds. No interest in Alaska can afford to allow the same mistakes which have been made in the lower Pacific states to decimate the Alaskan salmon runs. It will be far cheaper for all concerned to protect the salmon runs with stringent watershed management measures while seeking greater knowledge, than to try to rebuild the salmon runs once damaged.

4. We need continuing revision of fishing regulations to accomodate changing conditions, increased knowledge, promotion of quality, and the best opportunity for industry to carry out its responsibilities with realistic efficiency. I don't think we need any precipitous revision of the legal or economic structure governing the industry, but we need to remain flexible.

While I categorize these areas as primarily those of government responsibility, industry should be consulted with and participate in forming the policies which will lead to their accomplishment. Because, without the industry (and again I define it here to include fishermen, processors, and workers) in a healthy state there will be little need to achieve these goals.

I haven't given any reasons as to why I consider the future outlook good. Basically they boil down to the opinion that given the opportunity to produce high quality protein food from a viable, renewable resource, managed by responsible hands on a scientific basis, the pink salmon industry has an excellent future. Although the future looks good it doesn't look easy and it will take all of our concerted efforts to make it good.

The industry is very much interested in and vitally concerned with the scientific work you are doing. I believe that you will find the industry cooperative and interested in taking the steps necessary to rebuild and sustain the resources as long as the basis for the measures is sound and is understood.

DISCUSSION

Mr. Thorsteinson: Do you think reduction in fishing effort should be voluntarily carried out by the industry, or enforced through regulations?

Mr. Gilbert: I'm generally opposed to limitation of entry through statute. Tools with which you can increase escapement vary from one fishery to the next in Alaska, British Columbia and the rest of the coast. If you can show the industry that you need increased escapements of pink salmon in certain districts, they will accept regulations to achieve this increased escapement.

ECONOMIC ANALYSIS AND THE FUTURE OF PINK SALMON

James Crutchfield, University of Washington, Seattle

I am delighted to be able to appear at this Workshop to present some comments on the economic future of pink salmon. I was particularly interested to hear, from the morning's discussion, just how intensely practical the work that you are doing is and really has been for a long time.

First, let me take a look at the future of the demand for pink salmon from an economist's point of view, though I find that I can skip over it rapidly, since there are better qualified people here and their conclusions are much the same as my own. The long run demand prospects for salmon in general, and for pink salmon in particular, are very favorable. Basically, the demand for all salmon products should respond strongly to rising population and rising incomes. Substitution will always cut into the market for salmon if its price becomes excessive, of course. But the long-term price structure for salmon certainly could not be regarded as anything but good, assuming that the industry does its job with respect to full and effective utilization of the raw materials and that it promotes its products inteliigently. On this score we should have little to worry about.

The real key to the economic future of the salmon industry lies on the supply side rather than on the demand side: on an active program of protection, enhancement, refinement of fishing techniques, and better forecasting.

We all agreed that the salmon industry cannot exist without active management of the resource; the reasons for that don't need to be pushed any further with this group. But management must certainly rest on an adequately conceived and executed program of research and development, and these do not come free. I am a little jaundiced about the extent to which we can continue to expand the physical availability of salmon without running into completely prohibitive costs.

It seems to me that while the industry can expect to make significant progress over time, it must be, more and more, a kind of inward-looking process: a combination of government and industry activity designed to increase steadily the efficiency with which we use the resource at every stage of production and marketing.

From my standpoint, this calls first for attention to the objectives of management and of the research and development activities on which management rests. Have we really defined clearly our objectives and a systematic way of establishing priorities in terms of those objectives? To be perfectly frank I am not convinced that we have a clear or correct view of the objectives of salmon management and research. As a result there is a good deal of doubt that management is making the contribution to the industry's welfare that it could; and I would argue that in the long run the economic health of the salmon industry, in every phase of its operations, is the prime measure by which you judge the effectiveness of research and development work.

What are the objectives of salmon management at present? As far as I can tell, there is a fair number of salmon programs for which I can find no objective at all. They simply grew and having grown, stayed. There is a larger number of programs in which increasing scientific effort has centered on the apparently simple and unambiguous goal of maximizing sustained physical yield. Unfortunately, this goal is not simple, it is anything but unambiguous, and, to top it all off, it is incorrect. Let me see if I can justify this apparent heresy. In the first place, there is no internal consistency to the argument for maximizing physical yield as an objective of a fishery management program. If, by physical yield, we mean the supply of edible protein foods from the sea, the capital and labor now devoted to the salmon and halibut fisheries (the two in which management effort has been greatest) could produce a far greater yield in terms of edible food of relatively good quality by catching a wide variety of other species. And this leaves wide open another question, which I will not try to answer, as to whether more food, protein or otherwise, could be produced if the same amount of capital and labor were devoted to non-marine products.

There is no evidence whatsoever that the salmon program is in fact dedicated to maximizing sustained physical yield of the marine protein products to which the capital and labor engaged in the fishing industry can be applied. What we are really saying is that we are trying to maximize the physical yield, as best we can, of "valuable" species. But this introduces an economic value component. We will, sensibly, put research and management efforts only into those fisheries that are "worth it," that are valuable in terms of market prices. If rationality requires maintaining or increasing the gross value of the catch, it requires equally that the economic cost of the operation be as low as technical knowledge permits.

Unfortunately, cost considerations have been largely ignored in salmon management - and, for that matter, in all other fishery programs. They are taken into account, in a kind of hardheaded, practical way, in the sense that any good administrator, when he has a choice of options, some of which are more costly than others for the same expected results, makes the appropriate choices. But he is frequently in the ridiculous position of having to justify that sensible procedure by finding some biological reason for it. If he can't find one he will invent one so that he doesn't violate his terms of reference, since in most cases he is precluded from taking any action on a purely economic basis.

The objective of maximum sustained physical yield does not seem very meaningful to the economist. It is a kind of halfway measure, really involving maximization of some unspecified economic magnitude (by economic I mean, in the broadest and proper sense of the word, the contribution to aggregate human welfare of the society of which we are a part, including both producers and consumers). I am simply arguing that if it is true that our efforts are guided by the market to produce the things that are most useful to us, we must also look very carefully at the need to economize on the inputs that go into producing those useful things, so that we can have other things as well.

The words "maximum net economic yield" seem to have all sorts of frightening connotations for non-economists. The phrase is almost always accompanied by a walk to the blackboard where some incomprehensible flute music is put forth. This procedure is required, of course, to demonstrate that you are a professional economist, and I presume that it applies to biologists as well. Unless you can make mathematical noises, you are no longer acceptable. Since I have great difficulty in differentiating the simplest functions, I will refrain just this once.

The concept of maximum net economic yield, stripped of the flute music, amounts to saying that whatever be the coice of catch level which your scientific efforts suggest as alternatives, it is critically important that you bend every effort to direct or permit the industry, in its own interest, to use the most economical methods of taking that catch. I think it is fair to say we have failed completely even to specify efficiency as one of our objectives, much less incorporate it as an element in choosing methods of regulation.

Maximum economic yield involves maximizing over time the difference between the present value of what the industry (with your essential assistance) produces minus the cost of turning it out (including your own costs of operation). Much of the opposition to this objective seems to reflect the tendency of economists like myself to work from ideal models back to practical applications, which inevitably are sub-optimal systems modified to take account of political realities, insitutional rigidities, and the ways in which the industry has become adjusted to certain ways of doing things. These eggs simply cannot be unscrambled in a short period of time. I am afraid we've put all of you off by sketching the ideal model, and since all of you have spent a lifetime dealing with the practical obstacles involved, the whole idea is thrown out as not being worthwhile.

In a practical sense, improvement of the economic yield from the pink salmon operation is not a matter of ideal systems, but of indicating ways in which we can move from worse to better. This may have to be done in relatively slow steps in some cases, but in others I think it might well be possible to move rather rapidly. But in no case would any responsible economist or administrator argue that we start with the ideal and then tear the industry to bits in order to assemble that perfect operating system. There is a great deal that can be done, in the orientation of fishery management and procedures for establishing priorities for research and development work, to move us in the direction of greater economic efficiency. If the biologist is happier with maximum sustained physical yield (which I don't think he can define very sensibly), so be it. I would be more than willing to settle for maximum sustained yield, however defined, if I could ask in return that we look carefully to see that we have chosen that combination of regulations that results in the least costly operation to harvest it.

If we could get that far, I think we would have gone a long way toward assuring the future of the salmon industry; and to be perfectly frank, that future is unsure as long as we face the prospect of getting down to one and two day fishing weeks in many areas. In the second place, it should be possible to improve tremendously the accuracy of the feedback system whereby the industry provides information to researcher and regulator. As long as we are laboring, with thumb in the dike, to prevent an obvisouly excessive amount of gear from damaging the resource irreparably, the kind of information generated by the fishery and the interchange of information between industry and management authority is far below what is needed - and potentially available.

Thus, it seems that there is much to be said for the idea of viewing economic gain to the industry as a primary (though not only) objective of salmon management. Another very important aspect is the competitive need for progress in reducing the overall costs of the operation and of freeing the industry and the individual operator within the industry to develop and adapt new and better techniques. What possible incentive is there for improvement of salmon fishing techniques under the present regulatory program? Most specific regulations are either designed to reduce gear or vessel efficiency or produce that result as a side effect. As long as there is far too much fishing capacity, anyone who introduces a new and efficient technique forces us, of necessity, to find some new regulation that will blur its efficiency enough so that it doesn't increase the total effort directed at the resource. But surely this doesn't make much sense in a private enterprise economy, particularly when salmon has competitors, both at home and abroad.

This has some fairly obvious implications for management policy. I don't think anyone would argue the need to choose one or more ways of reducing fishing effort where scientific research indicates the need to do so, but past policy seems to assume that the various ways are all exactly equal as far as their effect on the economic welfare of the industry is concerned. They obviously are not. There is a tremendous difference between efficiency of the individual unit and efficiency in the overall sense of having the right number of optimal units operating in the fishery. In the former sense, I see no particular reason why we should interfere with the normal drive by private enterprise to improve the efficiency of its individual units. Still, we do precisely that, largely because inefficiency in the broader sense - the fact that there are far more units in the fishery than we really need - makes it impossible to do otherwise.

The question remains: how should we reduce fishing effort when it becomes necessary to do so? There are only a limited number of basic techniques, and it seems reasonable to look for ways of choosing a mix that combines reasonable short run efficiency, in the sense of the minimum number of optimal units, with the inevitable additional capacity required for flexibility, Obviously, we can never eliminate area closures, time closures, and some kinds of equipment control in an industry subject to as many variances around expected values as this one. But if the prime reliance were placed on reducing the number of units to some sensible level, we could not only expect a far healthier industry, but could use the remaining flexible instruments of control with more assurance and safety than at present. These are complementary, not competing, techniques of management.

This line of argument suggests also that fishery should be developing some key measures of the economic well-being of the industry. I would defy anyone to tell me what incomes are earned by fishermen in the various segments of the salmon industry. I would defy anyone in the Puget Sound area to tell me what price is actually being received for salmon. The "fudge factor" that one has to apply for the under-the-table payments (which everybody knows about and nobody wants to talk about) ranges anywhere from 10 percent to 25 percent from year to year. In doing some research on returns to fishing vessels several years ago, it was amazing to discover for the first time loans that bear no interest, and, in some cases, fishing vessels that apparently don't use fuel. Most unusual! It is very nearly impossible to determine what prices are being received, what incomes are being earned, and the extent to which the salmon fisherman depends on outside jobs to supplement his income. Many also draw unemployment compensation, good year and bad, thereby shifting part of the labor cost of the industry to the shoulders of other contributors to the unemployment insurance program. These are factual matters that are vitally important in assessing the health of the industry and the success of the management program. Yet we have no reliable statistical series to measure changes in them, and we have no facilities in either Federal or State agencies to develop this kind of information on a local or regional basis, and to give the administrator some solid basis for appraising the economic effects of his programs.

In the few minutes left, I would like to suggest two other significant contributions that economic analysis can make to improve salmon research. I have had to testify on a number of occasions on the contribution of salmon fisheries to economic output as a means of defending the claims of the salmon industry, both sport and commercial, as a competing user of water. As the argument above suggests, it is very difficult to find any case in which the net economic yield, as the Federal agencies are required to define it, is not zero or even negative; that is, the value of the catch is either at (or in some cases, below) the total cost of production. I don't think it makes any sense to argue that we ought, for that reason, to eliminate salmon fisheries wherever they are competitive with power, irrigation, flood control and municipal water supply. But I would argue that as long as we pay no attention whatsoever to the effects of salmon management on costs, we are going to find it difficult to make any kind of a case for salmon as an efficient water user in multiple purpose river development programs, and the more stringent standards for benefit-cost analysis in procedures now required of all Federal agencies will make it even rougher in the future.

Finally, with regard to the problem of economic analysis as a guide to budgeting research and development programs, I will lay out what sounds like a very strange position for an economist. I have a feeling that the Federal government, in particular, has gone a little overboard in the application of benefit-cost analysis in the evaluation of research and development. There is no question that a considerable amount of applied research and development work, much of it of the sort which all of you do, is amenable to this kind of analysis. While you can rarely measure exactly the dollar benefits from your work, there are many cases in which the choice among projects is a choice among alternatives, the benefits of which, as far as you can see, are roughly equal, but where the costs are significantly different. You make the best possible use of your limited research dollars, when projects are a trade-off as far as results are concerned, by choosing the cheaper ones. By the same token, where projects have roughly equal costs and you can make a qualitative judgment as to which ones promise the best results, both commercial and scientific, you have a basis for more orderly budgeting.

I had better not dig into such delicate matters as to whether you might, through economic analysis, make some interesting discoveries about the allocation of salmon funds among the Columbia River, Puget Sound, and Alaska areas; but I suspect that if someone were to take a careful look, it would not be surprising to find that reallocation of budgets might give the salmon industry as a whole a good deal more for a given number of research dollars.

But these cases, in which benefit-cost is directly applicable to fishery work, are not the whole story. Fisheries, like many other areas of government research, are beginning to suffer from the great pressure to justify <u>all</u> programs in terms of commercial, or at least measurable outputs. There is a real danger that this will generate a tendency to warp programs in the direction of those that can be measured in benefit-cost terms. As the pressure from the Bureau of the Budget to use the technique builds up, the tendency to shift toward mission-oriented work of an essentially short term character may get very strong. Yet I, as a non-scientist, would be inclined to argue, perhaps even more strongly than you, that the vitalizing effects of basic discipline-oriented research that isn't subject to year-to-year budget scrutiny are essential to real progress. Without that kind of continuing contact with pure science, the applied researcher can run out of ideas and get out of date pretty rapidly.

Strange as it may seems, a number of economists concerned with this field are now arguing strongly that the best contribution from research, and the best balance between applied and basic, might be achieved by setting aside a portion of the budget for "free" research, leaving the agency to choose, within rather broad limits, the specific areas and the specific projects which it feels would contribute most to the vitality of both staff and program. To become excessively preoccupied with quick results is no more defensible than becoming excessively preoccupied, as has happened in the past, with things of such remote concern that they don't have to stand the test of visible results. Somewhere between the two, there is a balance that will produce, over the long run, a research environment in which people acting as scientists can make a major (and, in the case of salmon, absolutely essential) contribution to the health of an industry which, at best, faces very difficult problems in learning enough about its basic raw material to use it wisely.

THE FUTURE OF PINK SALMON

Robert E. Silver, Canned Salmon Institute, Seattle

I am chairman of the Canned Salmon Institute (C.S.I.). The name may sound more impressive than need be, for it is an "institute" on paper only. It is an organization of salmon producers; an arm of the Association of Pacific Fisheries, of which Walt Yonkers is the executive vice-president. This is an organization that is voluntary - the participants assess themselves at a pre-determined rate and the executive, or guiding committee is composed of voluntary workers who are engaged in the marketing of canned salmon. My job with the C.S.I. is a labor of love, so to speak, because it carries no salary. I earn my salary from the company I work for, and here too, it is appropriate for me to be in Ketchikan because my company, that is, the San Juan Fishing and Packing Company, is being absorbed or merged with the New England Fish Company. The New England Fish Company is quite a factor in the Ketchikan fishery scene.

I thought that I should give you that background, so that when I speak in terms of marketing, and the problems of marketing, it is more than just my ideas, of what someone else ought to do. We are, as a company, very actively engaged in and concerned with these problems.

While considering just what I might present to you - the future of pink salmon from a marketing view point - I was reminded of a song which was popular, I believe, long before any of us was concerned with such matters. The lyrics describing a lady of dubious character - remark: "She hasn't much future - but oh, what a past!" Not that I mean to imply that pink salmon hasn't much future, but I doubt if anyone will dispute that pink salmon has really had a confused, troubled, and at times even dubious past.

To approach the question from a marketing standpoint, the salmon business in general, and the pink salmon business in particular, differs from most other major food productions and marketing enterprises in the extreme variations in the production pattern, and the difficult (if not impossible) task of advance planning, because of the inability to predict or determine with any degree of reliability, the size of the coming season's pack.

Unlike tuna, the leading canned fish item, pink salmon is produced in only one part of the world - the North Pacific Ocean. In the United States, we are primarily concerned with the marketing of U.S. production (Alaska and Washington).

We must sell what is produced in that one limited area of the world. This has been a mixed blessing. If our pack is good, there is little danger of foreign imports creating a marketing problem. Conversely, however, in terms of short production, little or no salmon is available from other countries, to help maintain the retail grocers shelf space with consumer familiarity with the product.

An ideal marketing program for any product would visualize production which could be controlled in volume, increased or decreased as market conditions warranted; which could be controlled in quality, produced at a predetermined cost, held within a reasonable variation and range, and which would be reasonably attractive in comparison to other products competing for "Mrs. Consumer's" attention. Pink salmon has had none of these attributes! To the contrary, pink salmon has been the antithesis of all that might be desired in a product for an orderly, constructive, and effective marketing program.

If we examine the United States catch of pink salmon from 1916 through 1965, we see that in 1936 production was 4.5 million cases; in 1941 it was 4.8 million. An annual production of one to four million cases of pink salmon was common throughout the twenties and thirties. On the other hand the production for 1957 was less than one million cases; in 1958, 1.5 million; two successive years of less than a million cases, followed by a number of years of almost two million cases each.

What does this tremendous variation in production do to the marketing picture? Since we can't control the production value we must adjust to the value that we have produced. When we have a shortage leading to pressure to buy, the price adjusts to meet the available supply. The law of supply and demand (which may be a fiction, but fiction or not, it certainly is applicable in the food business) works to the point that the packers raise the price to slow the movement so that there will be enough to go around. The price rises also help to offset increased production costs which are encountered when you have small production and a great many pre-season fixed costs; but regardless of the reason, the price goes up and the desired effect is accomplished - movement is slowed. If, in the following year, there is a tremendous production, the rate of movement is perhaps only one-third the rate that is needed to liquidate the total available supply in that given marketing year. So you have the same tremendous pressure pulling the price downward, and the food trade seems to have a great indifference to the cost of production. They are not particularly concerned whether a product that is selling for $10 cost $5 or $50 to produce. They are interested in marketing it competitively, and if it is a popular item they want to be assured of a supply; but whether or not the producer can operate at a profit is the producer's problem. The trade naturally doesn't like to see any producer or group of producers lose money on their production. But, when a seller goes to a buyer and says he is losing money on the transaction, the buyer assumes if you are in business you are making money or otherwise you would no longer be in business.

Let us consider the question of quality and its affect on marketability, insofar as pink salmon are concerned. Within a certain framework of quality, the product is marketable, there is a good demand for it and unless the quality drops below this level, the marketing should not present too much of a problem. I have reason to agree that it would be nice if we had a product without skin and without bones, but a good case can be made for the food value in the bones and the fact that in processing canned salmon, the bone is treated in such a manner that it is wholesome and edible and contributes to nutrition. This is very good, because I don't think that we want to contemplate a drastic change in methods of processing at this time.

Last year, we had a huge carryover of such salmon. We were still suffering from the poor pink salmon production of years 1959 and 1960. Due to these two relatively short production years, the price of pink salmon had risen to a new high; movement had slowed, and then the pink production jumped; but the price that was paid for the fish was the same as during the years when pink salmon was scarce. Therefore, there was an understandable reluctance on the part of producers to lower the selling price, with the result that movement was maintained at a rate more or less consistent with the shorter supply, and we had what we refer to as a carryover - a buildup of unsold stock.

The following year we had another bumper crop, the buildup continued, and finally the price of pink salmon started to drop. Once the drop began it was like a toboggan - it just kept going down and each packer seemed to try to outdo the others in getting his price down first, so that we could get the "next order" from the trade. The end result was a price at least 33-1/3 percent lower than the high - created by production in 1959.

To some extent, at least, the extremely low selling price failed to reflect carrying costs as well as production costs. We had selling prices that were well below the cost of production, at which time we obtained the rather cynical reaction of the trade that it was too bad, but since many packers seemed eager to sell at these prices, they must be "good" prices. But the cost of production was only reduced to the extent that larger production volumes would tend to reduce the actual cost per case of the finished product. I think the fixed costs remain fairly constant.

Recognizing the seriousness of the problem, the industry undertook to create a greater demand for the product (pink salmon) bearing in mind that we have 175 to 200 million people in the country, and that we are talking about 3 million cases - this is only 150 million cans - I'm talking now about total salmon production rather than just pinks. If we could achieve a consumption of one can per person per year, which really isn't very much, our problem would be solved. Furthermore, if we could get the average American family to serve salmon three or four times a year, we would have an actual constant shortage and a very healthy demand.

In the 1920's, canned salmon enjoyed a per capita consumption of 2.16 pounds; tuna, 0.18; by the 1930's salmon consumption had risen to 2.34 and tuna, 0.40; by the 1940's salmon consumption had dropped to 1.36 and tuna was up 0.63; in the 1950's salmon consumption had dropped to 1.17 and tuna was 1.47 and in the 1960's (this survey was made in 1964) canned salmon consumption had dropped to 0.8 pounds per capita per year and tuna had risen to 2.05.

It is rather frightening to see the steady drop in salmon, and yet, when you examine production records, it is apparent that one of the reasons for the drop in consumption was the drop in production. If we had more salmon available, the per capita production would have risen. Once the question of conflict of price was resolved, with the huge pink packs of 1963 and 1964, the per capita consumption had to rise, if we were going to dispose of the pack. It is at this point that I would disagree with John Gilbert, who questioned the role of government in marketing. Being concerned with effective marketing of pink salmon, my feeling is that any agency that can do the job and can help us is one to be encouraged; and we want help wherever we can get it, to whatever extent it is available. The Bureau of Commercial Fisheries, in their own right and through their liaison with the U. S. Department of Agriculture, provided tremendous aid in this marketing effort. First, they helped during the years when pink salmon was plentiful. Now that pink salmon is scarce, we have enlisted their aid with regard to red salmon. The various activities that are spearheaded by the Canned Salmon Institute, aided by the government and to a very significant degree by the individual efforts of the various producers themselves have created a tremendous impact on Mrs.

Housewife, to acquaint her with canned salmon, extol its virtues, and induce her to buy it again. The surveys indicate that perhaps only one woman out of five uses canned salmon, and perhaps only one out of ten uses it with any degree of frequency. Therefore, there is a vast field of potential customers to address our various efforts toward. We have utilized all these various areas of approach; industry efforts, government efforts, re-education of the consumer starting at the high school level and continuing on through college, through the home economics department. We created a school kit - a kit that the teachers could give to the students explaining what salmon is, the various kinds, how to prepare good, tasty economical and nutritious recipes. This program is continuing, and it is bearing fruit. Some of the programs that we have developed, have been most widely subscribed to by home economics teachers. We have also attempted to increase institutional use of salmon, and increase its use by the military. Good and proper use of canned salmon in military feeding should result in consumers returning home with a fine recollection of salmon, and continuing to use it. This, of course, depends on the recipe that is used and just how it is used. We went so far, at the time when pink salmon was over-abundant (we thought), to try to convince the military authorities that pink salmon was suitable for military feeding. We got some very fine reactions from the troops to whom patties and croquettes were fed. I think the prize response to one test at Fort Lewis was that of the Sergeant who remarked, not knowing what he was eating, that it was Friday, and that "this sure beats eating fish on Friday." We have a commitment that the use of canned salmon was to be increased 25 percent during fiscal year 1966, and an additional 25 percent during fiscal year 1967.

By and large, however, the direction of our efforts should be to civilian consumers. One of our primary tools to create demand has been food page publicity. Unless the food retailer gives salmon a "break" in his store and on his shelves, everything else may be wasted. The old attitude, and when I say "old," I mean four or five years ago, was that salmon was a slow mover, and that it took up a lot of valuable space that could be better devoted to more profitable items. We have been able to elevate the position, as well as the status, of canned salmon in the retail grocers.

In order to watch the movement, we are working with the National Canners Association, Washington, D.C. office. Salmon producers are a group of rugged individualists, as you have all observed from time to time.

They don't particularly want to disclose anything about their activities to outsiders, primarily because they don't want their competitors to find out. But working with the National Canners Association, we have now created a statistical observation of the available supply and movement, month to month, so that we can gauge how successful our efforts are, and how well the pack is moving. This information released once a month, may be several months old by the time it is issued, but it does provide a reliable guide to follow, in planning an orderly marketing program for canned salmon.

What is going to happen when we have a good salmon year? We will again be faced with the cycle of feast and famine. Even though we currently have a big pack of red salmon, this doesn't mean that it takes up the slack of pink salmon. The two are companion items, but not necessarily substitutes for one another.

I have two areas that I still want to cover; one is the space in the magazines and newspapers of the country that canned salmon has received. This is all salmon, not necessarily pink salmon, but by and large when the emphasis was on pinks, the reports, the newspaper stories and the recipes tended to favor or recommend pink salmon. This year our emphasis is on red salmon, because it is the abundant item. The public relations work of the Institute is done by a professional organization, the firm of Cole and Webber, who are in the advertising and public relations business.

In 1958, canned salmon was mentioned in 935 newspapers and magazines with a space of approximately 15,000 inches and a total exposure circulation of 50 million. This is for the entire year and entire country. In 1965, canned salmon was mentioned in almost 9,000 papers and magazines - almost a 10-fold increase, receiving 81,000 inches and a total circulation of 525 million, which is a tremendous upsurge.

Had we tried to buy this space, the cost for 1965 would have been 2-1/2 million dollars, and bear in mind that you might buy the space to run an ad, but you couldn't get Prudence Penny or Dorothy Neighbors, or whoever is writing the column, to give you her recommendation, which carries a great deal more weight than a simple advertisement alone. Over this period of eight years,we calculated that there has been more than 10 million dollars worth of space, and you can't begin to measure the value of the good will and publicity that was actually created.

Related to the time when we were faced with problems regarding pink salmon, we as an Institute contacted the food trade, the large companies, the small companies and the in-between size companies; the wholesalers, the retailers, and trade associations, asking for their support. The response was unbelievably good. I have here a letter from Safeway Stores, which is the number two retail chain in the U.S. I purposely didn't bring anything from the "number one" chain, because they are also in the salmon canning business and you might think they would be somewhat biased because they are producers. But I will say that they did get behind the pink salmon promotional efforts to a degree above and beyond the fact that they were in the salmon business. But this is from Safeway and the letter states, "as you say, canned salmon has been good for the trade and to the trade for many years, and we are glad of the chance to give it a boost." That's from Safeway. A letter from the Kroger Company says "in line with your request to promote canned salmon, we thought you would be interested to know that our orders for pink salmon were approximately 260 percent ahead of the corresponding period last year." Kroger is the number three chain in the country. We have similar letters from National Tea Company, which is another major national chain, and from the Supermarket Institute, the organization that sets the guidelines of procedure for the supermarket organizations. This one goes on to say that "we realize the seriousness of the salmon industry's problem, its affect upon the economy of Alaska, and we promise to do our utmost to help." These are just a few of the letters promising support, which were followed up by actual support and, by such a tremendous uplift in the movement of pink salmon that what seemed to be a burdensome surplus became, in one year, a shortage.

To summarize, I agree with Dr. Crutchfield that the problem is one of supply. As an industry, give us the quantity that represents the maximum output of the fisheries, a quality that we can be reasonably proud of, at a cost structure that will not place the product in a class where it is not impossible to sell. Based on what we heard earlier today, I am not sure that the immediate future looks that good, but we will certainly hope that in the next few years you will give us the production we need to maintain this interest.

DISCUSSION

Mr. Kilambi: You have written quite a bit publicizing salmon products by putting ads in the newspaper or magazines, but I don't think I have ever seen any canned salmon commercial on TV. You have indicated consumption of tuna is 2.05 pounds per capita and that salmon is only 0.8. Maybe it is because tuna people are using more TV commercials.

Mr. Silver: It is a good point, but let me clarify what may be a misunderstanding. What we have done as an Institute does not represent paid advertising. This is publicity in the newspapers and magazines without actual cost other than the cost of developing the recipes, providing the photographs, providing the basic information to the food editors, who do the rest. We did not attempt to measure the advertising done by the individual companies. I would guess that while it doesn't approach the efforts of the tuna industry, that a tremendous amount of individual company's brand advertising is done on television, as well as in the magazines and newspapers. Furthermore, we have received a great deal of television support from other companies who seek to tie in with our product to help foster the sale of their products. A good case in point is Kraft foods. Kraft Cheese Company of Kraft Foods, makers of Miracle Whip, and so on, have during Lent and other times during the year, not only advertised salmon along with their product, but have also shown a very attractive housewife making the recipe right on television; opening the can of salmon, and putting it into the dish right along with, naturally, the Kraft product that they are publicizing. Use of television is not being overlooked. In the support that we get from the Bureau of Commercial Fisheries and the Department of Agriculture, there is a great deal of public service time which is not perhaps key interest time, but which, nevertheless, in the aggregate represents quite a sizable amount of time, and which, as a public service in order to perhaps keep their licenses, is taken to broadcast what the government agencies request that they broadcast. The use of canned salmon is given a great deal of attention in that area.

Mr. Mattson: What proportion of salmon processed in the U.S. is sold to foreign markets?

Mr. Silver: It will vary and will depend on the relative production in Canada, Russia and Japan. If production in other nations is high, our sales to foreign markets is lower because the other nations operate on a lower price structure and we find it difficult to compete. Last year (1964) exports of salmon were large; this year (1965) there is no pink salmon available for export because we don't have enough for the domestic market.

Anon: Why isn't pink salmon packed in 1/2 pound cans like tuna?

Mr. Silver: Until recently the price of canned tuna has been considerably lower than the price of canned salmon, even in the half pound size. Pink salmon is traditionally used in the U.S. as a cooked family meal, a substitute for meat; not as a snack or sandwich filler. A major objective of the Canned Salmon Institute is to develop more sandwich recipes and use for snacks and sandwiches.

TECHNOLOGICAL CHANGES IN SALMON CANNING

Walt Yonker, National Canner's Association, Seattle

In the late 1920's, the salmon canning industry was looked up to by the entire canning industry as a progressive, forward looking segment of the food processing industry. The salmon canning industry had the fastest canning lines, the most modern filling equipment, the most modern retorting systems and a product with excellent consumer acceptance.

The industry generally held this position into the early 1940's. In the 1950's, other segments of the canning industry began to make considerable progress in raw material supply and handling, plant equipment, and in merchandising. At the same time the salmon industry was plagued with serious problems of changing methods of catching fish and with declining runs of salmon, both of which combined to make financing of more modern plants and equipment impossible.

This industry has gone through a fifteen year period of which its financial and production efforts have been directed primarily toward increasing the fishing effort with lesser attention being given to plants and equipment.

In the last three years, with indications of better salmon runs and sufficient fishing boats to assure a supply of salmon for the canneries, the industry is turning its attention to improving the neglected technical areas of production.

With the change of catching methods from traps to boats, it was of primary importance that improved methods of handling the fish from the grounds to the processing plant be developed. The industry turned to the use of refrigerated brine or saltwater to furnish better quality raw material to the plants. This was not a new development in the fishing industry as this type of handling was used in the sardine industry in the late 1920's; but new techniques and tender equipment had to be developed to handle salmon. A typical system consists of holding tanks filled with seawater which is pre-cooled to approximately 28°F. These systems circulate the brine through a chiller and have a capacity of about forty pounds of fish per cubic foot. They have the advantage that the fish are floating and are not crushed by deep loads.

The industry has recognized that the quality of fish begins to decline as soon as they leave the water and that the best techniques are important in delaying this loss of quality. For this reason, a number of operators have also installed brine tanks at the cannery to minimize quality losses while the fish are being held for canning.

In the last two years we have also seen the use of antibiotic ice for canning fish developed when icing is called for.

Using refrigerated seawater, antibiotic ice and faster tenders, the canner is now able to deliver the salmon at the plant in good condition for canning.

At the same time, several changes were being made in the plants which improved the quality of canned salmon. Line speeds increased from 125 cans per minute to 240 cans per minute, and new lines are operating up to 320 cans per minute.

To assure that these faster lines deliver a good canned product to the consumer, new "Iron Chinks" (the Model K) were put into use. They are not only faster than the old butchering machines, but also more efficient. Canners have also installed sliming machines in place of the old hand sliming method. These machines are not only faster than hand cleaning, but decrease the work load for the inspectors and finishers so they may more readily put a properly cleaned fish into the canning line.

Within the last two years, this industry has also increased its efficiency in handling canned salmon from the canning line to points of distribution. Several plants are now using the Busse system for handling cans from the lines to the warehouse. This system automatically loads cans from the line into baskets prior to retorting and automatically unloads these same baskets for casing after the retorting is completed. At the present time some operators are now shipping cans, without cases, on pallet boards. Approximately 40 cases of cans are placed on a pallet board and overwrapped with corrugated board and strapped for shipment from the cannery to distribution points. This latter procedure saves the costs of cases as most of the salmon is labeled at some central distribution point, eliminating the loss of cases used in southward bound movements.

In the continuing effort to deliver better quality canned salmon to the consumer, repairs and improvements are being made which lend themselves to improved general sanitation. A majority of the plants now have sanitation programs which take advantage of new detergents and sanitizers and new equipment which improves clean-up procedures.

Several of the procedures which I have discussed up to this point, refrigerated brine handling and faster lines, are decreasing the quality loss of salmon after it leaves the water. Other advances are concerned with improved efficiency of operation which offsets rising costs in an attempt to maintain salmon as a market and not a delicatessen item.

The important consideration at this workshop is, where do we go from here?

I feel that development from now on will be in areas of increased use of what is now considered salmon waste, variation in container sizes and styles and in the development of new products. All of these possible improvements pose, for the present, some very serious problems which prevents their adoption by the industry.

We have seen the use of salmon heads for the manufacture of oil become a reality. The use of salmon eggs has changed from a casual sport bait business to one which used 1.5 million pounds of eggs in 1965. When problems of power for reduction of waste can be resolved and southbound freight rates can be reduced, it may be possible to profitably make meal and oil from salmon waste.

A future possibility for changing techniques for canning salmon may be concerned with cans. At the present time the industry is using six different can sizes, which seem to satisfy the demands of the consumer. We are faced with two problems in the container field; one is that consumer advisory groups are asking for fewer can sizes and uniformity for container sizes between products, the other is the fact that at the time of peak salmon runs, to preserve quality by canning fish as rapidly as possible, it is necessary to go to the standard one pound tall can. With the very rapid advances in the container field the past few years, it may well be that entirely new types of packaging may be available which will change this picture.

New products are an obvious consideration in improving the use of canned salmon. At the present time we have one major producer who is doing experimental marketing with a pink salmon patty, with promising results.

Advances in air service throughout the world will improve the ability of the industry to market frozen and fresh salmon on a much wider scale than has been possible.

The industry has also investigated the production of canned skinned and boned salmon, but has not been able to develop machinery which will operate at necessary production speeds. Nor has the industry been able to solve the loss in yield which would be passed to the consumer for this higher priced product.

Since its inception the industry has come a long way and with the technical know how available and the rapid development of canning technology, we can expect the industry to continue to improve the quality of its products. We know that we can continue to depend on you here to provide a raw material that is of a quality which is commensurate with the selling price. You are not just producing salmon and the canning industry is not just producing cases. Together we are producing food.

GENERAL DISCUSSION

Dr. Bevan: Many of you have been asked by fishermen and other interested persons what happend to the pink salmon run in 1965? Are we fairly well agreed that we just don't know, or can we, at least in part, explain the failure? Are we fairly certain that we had an excellent outmigration in a number of areas and can we then say that survival was poor in the marine environment? Was the failure uniform along the coast in early runs as opposed to mixed results in late runs? Collectively we had a good view of what happened last year and I should like to see if we have an answer.

Mr. Noerenberg: I think the general opinion is that this unusual shortage of pink salmon occurred all along the coast in the same magnitude. I feel however, that the reduction was much more severe in the south and gradually tapered off to the north. Runs in Kodiak, Prince William Sound and Cook Inlet were about as we had forecast after an examination of fresh water mortalities. In Southeast, the early runs were definitely reduced. We did have an increase over the previous cycle in two areas in Alaska; i.e. the outer part of the Ketchikan area and the western section of the south Peninsula area.

Dr. Parker: I have some data that might have some bearing on this question, but its only for the Bella Coola stock. For the past 4-5 years I have been trying to estimate ocean mortality for the first 40 days and the remaining part, up to 450 days from the time of entrance into the sea. In the 1960 brood year, returning in 1962 and producing 16 million fish in the Bella Coola area, fry to adult survival was 22 percent. In the 1961 brood year, returning in 1963, survival was 5.2 percent. In 1962-1964 survival had dropped to 4.4 percent and in the return we just had (1963-1965) survival was 1.9 percent. During the first 40 days, in 1962 mortality was 77 percent; in 1963 it was 55 percent and in 1964 it was 59 percent, so the mortality of the 1963 brood year was not excessive, in fact was lighter early in the coastal period. It is apparent that, as far as the Bella Coola stock is concerned, an unusually severe mortality took place after the initial coastal period.

Mr. Roys: What was the outmigration?

Dr. Parker: It has varied from 32 to 61 million from 1962 to 1964. Thirty-two million fry in 1964 could still have produced a good run of fish. These estimates of sea mortality rates should destroy anyone's faith in a constant sea mortality rate. I don't, however, know if the figures I have given you have coastwise application.

Dr. Bevan: Yesterday Bud Jewell mentioned the lack of outmigration in the Nooksack, in spite of the very high escapement of adults in 1963. When Dick Tyler tow-netted in Bellingham Bay in the spring of 1964 we expected to find pinks in substantial numbers. We were surprised to find very few pinks and a pink-chum ratio of about 1 to 25. There obviously was a small outmigration from the tremendous spawning escapement. Perhaps Bud Jewell has information on other parts of Puget Sound or the Fraser.

Mr. Jewell: The Salmon Commission felt there was an abundance of outmigrants and there did not appear to be a decrease in the San Juans on the way out. Our own sampling is too new to attempt comparisons. We did know what our chum population was doing and any time the chum-pink ratio was high we knew we were in for trouble. There are relatively few chum in the Nooksack and the ratio you mentioned indicated we would have few pinks returning. In December

1963 the major spawning tributaries of the North Fork of the Nooksack were subject to severe flooding. There also appeared to be a high ocean mortality after we could no longer sample.

Mr. Noerenberg: From results of the tagging on the high seas no unusual mortality appeared in the last month or two at sea. Al Hartt reported a normal recovery rate from the F.R.I. tagging experiments. I feel there might be some meaning in the exceptionally low temperatures in the North Pacific Ocean during the summer of 1965. I don't know what this may mean with regard to survival during the late sea life stage.

Dr. Bevan: I think with regard to fishing on the high seas there is a real problem that must be solved. We look at catch per thousand hooks as some measure of abundance. If we do this we must have a better idea of the relationship between catch per thousand hooks and the abundance of fish. There is evidence to indicate that if the catch per thousand hooks is high, if the bait is missing from a large number of hooks because there are lots of fish around, or if there are other species on the hooks, the set of a thousand hooks becomes saturated. Because of this we might badly under-estimate high abundance at sea, or conversely we might over estimate a low abundance of fish. Last spring early indications on the east side of the Gulf and to the south were that abundance of fish was higher than it was two years previously. It is apparent now that this conclusion was not a correct one. We can offer as explanation that the fish were spread out over large areas in the Gulf and that this is a lot of water to cover with 5 boats using long lines that can only be set for short period of time each day. We are using these data to their maximum, and last spring the data was misleading.

Mr. Dell: We now think that when we get more than 100-150 fish per thousand hooks we are approaching saturation. Many times we observed almost all the hooks with bait missing and the pinks caught contained two or three baits in their stomachs. This means that sometimes we fished two or three baits before the fish was hooked. Therefore, if we get 100-150 fish per thousand hooks, this might mean that our catch should be double that number or even 500 fish per thousand hooks. We are going to correct this estimate next season by using Gulland's catch table which has been set up around an ideal long line fishery. This will enable us to allow for lost fish and missing bait.

Mr. Simon: How about over-estimation of abundance?

Mr. Dell: That is a possiblity, too. We are studying the comparative rates of catch of different sizes and different species of salmon to try and obtain a better understanding of this problem of over-estimation.

Dr. Bevan: It's clear there is no simple answer to what happened in 1965. We had two very bright spots, one on either side of the Gulf, perhaps only by coincidence at about the same latitude, and we had fairly uniform failure around the rest of the Gulf. We have evidence that late marine survival was responsible in some areas and that inshore or stream survival was responsible in parts of Puget Sound, Prince William Sound and Kodiak. I think this points up the real importance in being certain that we have a broad approach to forecast. It is highly important that we don't blind ourselves by throwing all our efforts in a single direction. Forecast research should proceed over a wide range of time and space.

Mr. Fredin: With regard to Bristol Bay sockeye, it appears that sampling errors could have accounted for the tremendous deviation of the run from the forecast -- errors in estimating numbers of smolts, escapements, abundance on the high seas and in establishing escapement return relationships.

Mr. Meacham: I don't think there is any question of the sampling being inadequate, especially when we apply proper statistical methods to the data and arrive at an incorrect answer.

Mr. Jewell: In Washington we are quite concerned with dropout from gillnets, the extent and impact on mortality rates. In a program we will initiate in the future we will examine dropout with television or divers and perhaps also use a sonic device. We will run these tests on a hatchery produced run of chinook salmon that returns through an inlet where the water is both quiet and clear. We will set a predetermined number of shackles of floating gillnets. There is also a good run of silvers that returns to this area and all the salmon eventually ascend a dam, enter the river and then a holding pond where every fish can be individually examined for net marks, etc.

Since we apparently have problems with chum salmon along the coast, is there a possibility of starting a chum salmon workshop? There are many differences between pink and chum salmon and I wonder if we have enough information to conduct a workshop?

Dr. Bevan: We discussed this problem when we first started the pink salmon workshop. At the present time there is no significant amount of research on the Pacific coast directed toward chum salmon. I do think the people doing research on chum salmon know each other, they know what they are doing and they are passing information along. I doubt if there is a sufficient body of people to make a chum salmon workshop stand alone. At the first Steering Committee meeting for the pink salmon workshop we decided to exclude chums. We may have been wrong, but I suggest we continue without a formal chum salmon agenda.

Mr. Walker: We decided two years ago that since the two species (pink and chum) are similar we could if necessary, include a discussion of chum salmon in the pink salmon workshop. I now suggest that the only similarity between the two species is that the fry of both emerge from the gravel and go to sea with little or no fresh water residence. We have found that chums have a different survival rate in the streams, in the estuaries, and in the ocean. Even though there are only a few individuals on the coast interested in chum salmon per se, there is a considerable amount of available data, enough to warrant discussion. I would welcome such a discussion.

Mr. Meacham: This question should be referred to the newly appointed Steering Committee for the 1968 meeting.

Mr. Martin: One outstanding feature of our coastal work is the absence of juvenile chum salmon in our catches. It's not because they are not there; its because pink salmon are so numerous they overshadow them. It would be difficult to extend our work to cover chums in certain areas. I would also like to comment on earlier discussions, those on the mortalities in the area of Bella Coola and relationship between abundance of fry and return of adults in Prince William Sound. Perhaps there is significance in the latitudes of which these areas are located. Bella Coola empties into an estuary over 60 miles long and juvenile pinks remain in this estuary for at least 40 days. In contrast, fry leaving the Karluk and some other river systems enter a highly saline environment immediately. Our work with temperatures indicates that higher survival is associated with lower temperatures. On the other hand I believe if the temperature is too low this too causes excessive mortality. Last spring surface water in southeast Alaska was abnormally cold because of the abnormally severe winter. There was a complete absence of parasites which had been numerous in the preceding year. Parasites may be a major mortality factor and in colder water parasitic infestation may be greatly diminished. I suspect that saltwater temperatures in the areas of Burke Channel and Bella Coola are higher than saltwater temperatures in southeast Alaska. Because of numerous glaciers Prince William Sound may have the lowest saltwater temperatures. All this points out the need for more information about the saltwater environment. If we are going to speculate on what happens after the pinks leave the estuaries and inshore areas we need more information. We should monitor the outer coastal section because there is evidence that the Gulf of Alaska and certainly the Central Pacific Ocean have varied considerably over the past few years. Variation in the coastal waters and along the margin of the gyre may be far greater. Water temperatures may be much more important than we realize.

Dr. Parker: The basic premise that all the fish are the same underlies all of our draft work, the correlations and linear regressions. I think we've got to go back and start looking at the fish. The highest run in the Bella Coola (a return of 16 million salmon) was the result of the highest freshwater survival ever recorded, followed by the highest saltwater survival ever recorded. Roughly the same escapement has produced, one year 55 million fry, another year 32 million fry. One had a sea survival of five percent, the other from the lower fry production of 1.9 percent. It may be those fry weren't the same quality to start with; perhaps when they entered the sea they didn't have a chance. Maybe we don't have to look for differences in sea surface temperatures and the number of sharks per square yard. It may have been the quality of the fish.

Mr. Roys: Last summer saltwater temperatures in Prince William Sound were relatively high, but varied from day to day. Perhaps some of our estuaries up there are similar to temperatures at Bella Coola.

Mr. Martin: Perhaps when the juvenile pinks move out of the estuaries they are moving ahead of high temperatures. Until we can define the entire migration out of Prince William Sound, we can't compare it with other areas under study. Does anyone know the location of the small pinks in Prince William Sound during the summer?

Mr. Roys: Only from May until the middle of June -- not during the late summer, although we have observed them in the outside areas later on.

APPENDIX

Appendix 1. Results of Questionnaire on Pink Salmon Workshop

Of the fifty Workshop participants, forty submitted questionnaires and of the forty, not all answered every question.

Question	Percentage Yes	Percentage No
1. Should workshop be continued?	100	0
2. Is a biennial meeting suitable?	93	7
3. Was length of meeting		
(a) Too short?	20	
(b) Too long?	10	
(c) Satisfactory?	70	
4. How many topics should be covered?		
(a) Two	3	
(b) Three	57	
(c) Four	40	
5. Is no-agency sponsorship satisfactory?	100	0
6. Should committee chairman arrange own style?	93	7
7. Should "standardization of terms and definitions" be reconsidered?	35	65

8.	Was quality of topic coverage adequate? (Suggested improvements were: more time for discussion and individual speakers; better preparation and more use of vis- aids by speakers; panel discussions should follow presentation of papers.)	83	17
9.	Are proceedings in the Bureau of Commercial Fisheries MR series, or Alaska Department of Fish and Game Informational Leaflet satisfactory?	100	0
10.	Should next meeting be held in		
	(a) Prince Rupert	53	
	(b) Anchorage	18	
	(c) Juneau	15	
	(d) Ketchikan	13	
	(e) Sitka	1	

11. Questionnaire asked participants to select four topics which they would like to have discussed at the next workshop and rank them in order of preference. Many people simply checked four topics, and did not rank. Each un-ranked check was given a value of 1 point. When topics were ranked, a primary ranking was given 4 points, a secondary ranking 3 points and so on.

Total Points	Topic
48	Basic studies on factors controlling abundance in estuarine and inshore waters.
46	Development of methods of forecast.
41	Effects of regulation on abundance of stocks.
31	Threshold or optimal escapement levels.
31	Basic studies on factors controlling abundance in freshwater.
26	Applied research on multiple use of watersheds and monitoring of salmon streams.
17	Distribution of stocks on the high seas.
16	Basic studies of factors controlling abundance on the high seas.
13	Applied research on artificial propagation.
11	Studies on stock dominance.
10	Distribution of stocks in the inshore fishery.
8	Sampling techniques and programs.
7	Economic evaluation of the resource and cost-benefit relationship.
5	Oceanographic studies.

In addition to the above topics which were listed in the questionnaire, eight participants listed additional topics as follows:

1. Recent findings in the ecology of pink salmon streams.

2. (a) Management applications of optimum escapement information.

   (b) Role of industry in management.

(c) New uses for watermarked salmon.

3. Discussion on homing.

4. (a) Condition and utilization of the pink salmon resource.

   (b) Interaction between conservation of pink salmon and other species.

5. (a) Gear limitation

   (b) Stock segregation

6. Separate, but simultaneous 4 hour sessions on freshwater, estuarine, inshore and offshore marine ecology.

7. Miscellaneous section covering physiology, parasitology, predation and migration.

8. (a) Salmon behavior

   (b) Predation

12. What are the three top research needs in order of priority? (First priorities 3 points; second priorities 2 points; and third priorities, 1 point)

Number of Points	Top Research Needs
43	Methods of forecast
32	Optimum escapement levels
29	Freshwater ecology
26	Segregation of stocks
15	Estuarine ecology

15	Marine ecology
6	Effects of regulation on abundance of stocks
3	Determination of total run
3	Collection of adequate basic data
3	Applied research on multiple use
3	Better marking techniques
3	Condition and utilization of pink salmon resource of North America
2	Environmental monitoring systems
2	Effects of logging
2	Economic evaluation of resource and cost-benefit relationship
1	Causes of cycles
1	Gear limitation
1	Spawning channels

13. This question, "Were results of the 1964 Workshop of value to to you in planning or conducting programs," was added during the meeting. The response, 6 yes and 34 no response, indicates that the question did not get across.

Appendix 2. Registrants at the 1966 Northeast Pacific Pink Salmon Workshop

Name	Organization [1/]
Aro, K.V.	FRBC, Nanaimo
Bailey, Jack E.	BCF, Juneau
Bevan, Donald E.	U of W, Seattle
Crutchfield, James	U of W, Seattle
Davis, Allen S.	ADF&G, Homer
Dell, Mike	FRI, Seattle
Fredin, R.A.	BCF, Seattle
Fridgen, Peter J.	ADF&G, Anchorage
Gilbert, John R.	Bumble Bee Seafoods, Seattle
Hartt, Allan C.	FRI, Seattle
Hennick, Daniel P.	ADF&G, Kodiak
Hirschhorn, George	BCF, Seattle
Hoffman, Theodore C.	ADF&G, Juneau
Hollett, E.L.	CDF, Vancouver
Jewell, Earle D.	WDF, Olympia
Johnson, Ray	WDF, Olympia
Johnston, Norman D.	ADF&G, Petersburg
Junge, Charles	OFC, Portland
Kilambi, Raj V.	FRI, Seattle
Koski, K.	FRI, Seattle
Larson, Charles C.	ADF&G, Juneau
Martin, John W.	BCF, Juneau
Mattson, Chester	BCF, Juneau
McCart, Peter	FRBC, Nanaimo
McHugh, Michael J.	ADF&G, Juneau
McNeil, William J.	BCF, Juneau
Meacham, Charles H.	ADF&G, Anchorage
Merrell, Theodore R.	BCF, Juneau
Nicola, Stephen J.	FRI, Seattle
Noerenberg, Wallace H.	ADF&G, Juneau
Parker, Robert R.	FRBC, Nanaimo
Pearson, Roger E.	BCF, Seattle
Richardson, Thomas	ADF&G, Wrangell
Rickey, Roy A.	ADF&G, Juneau
Rosier, Carl L.	ADF&G, Ketchikan

Name	Organization [1/]
Roys, Robert S.	ADF&G, Cordova
Salo, Ernest	FRI, Seattle
Sheridan, William L.	USFS, Juneau
Silver, Robert E.	Canned Salmon Institute, Seattle
Simon, Robert J.	ADF&G, Kodiak
Simpson, Lyle R.	ADF&G, Ketchikan
Smedley, Stephen C.	ADF&G, Juneau
Smith, Howard D.	FRBC, Nanaimo
Thorsteinson, Fredrik T.	BCF, Juneau
Tyler, Richard W.	FRI, Seattle
Valentine, John P.	ADF&G, Ketchikan
Walker, Charles E.	CDF, Vancouver
Wilson, Carl N.	USFS, Juneau
Yonker, Walt	National Canner's Association, Seattle

1/ Abbreviations used for organizations:

ADF&G	Alaska Department of Fish and Game
BCF	Bureau of Commercial Fisheries
CDF	Canadian Department of Fisheries
FRBC	Fisheries Research Board of Canada
FRI	Fisheries Research Institute
OFC	Oregon Fish Commission
USFS	Forest Service, Alaska Region
U of W	University of Washington
WDF	Washington Department of Fisheries